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CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

Synopsis of the Species of Oreodontidæ. By E. D. Cope.

(*Read before the American Philosophical Society, January 18, 1884.*)

The tribe Ruminantia first appears in the White River Miocene period in North American geological history. It is represented there by a number of genera, which pertain to several family types. The most aberrant of these, the *Oreodontidæ*, includes the largest number of forms, generic and specific. The *Poëbrotheriidæ* certainly embraces but few species, while a third group of genera, represented by Leptomeryx, which are intermediate between the *Tragulina* and *Pecora*, and should be perhaps regarded as aberrant *Tragulidæ*, also includes a small number of species.

The *Oreodontidæ* constitute a family related to the *Anoplotheriidæ* of the later Eocene, but representing a more specialized condition of the structure of the molar teeth, in the full development of the selenodont type, which is rudimental in the *Anoplotheriidæ*. Their feet, on the other hand, are less specialized than in the latter family. As a family, the *Oreodontidæ* display very little tendency in their limbs to the specialized condition of the *Ruminantia*, but are more like those of the suilline groups, and, among recent families, of the *Hippopotamidæ*.

OREODONTIDÆ.

Dentition; superior incisors present; molars selenodont. Cervicals with the transverse processes perforated by the vertebrarterial canal. No alisphenoid canal. Ulna and radius, and tibia and fibula distinct. Metapodial bones four on each foot, with incomplete distal trochlear keels. Lunar bone not supported by magnum. Navicular and cuboid bones distinct.

The preceding synopsis of its characters should furnish a basis for the definite location of the *Oreodontidæ* in the system. Dr. Leidy called its species Ruminating hogs, and created a family for Oreodon and the allied genera, under the name of *Oreodontidæ*. This family is adopted by Prof. Gill who includes in it the *Agriochoeridæ* of Leidy, and places it in his division *Pecora*, which is more comprehensive than the *Pecora* of Prof. Flower, being nearly identical with the *Selenodonta* of Kowalevsky. More precise expression of its affinity to the existing families is not given, excepting to place it under a division "incertæ sedis."

As a selenodont type, this family is excluded from the *Artiodactyla omnivora*, and as having its metapodial bones distinct, it cannot be placed in any recent family excepting the *Tragulidæ*. From this family it is distinguished by the distinct ulna and radius. We then turn to the extinct families *Poëbrotheriidæ* and *Anoplotheriidæ*. The former agrees with the *Tragulidæ* excepting in its Cameloid cervical vertebræ, while the latter differs from the *Oreodontidæ* in the structure of the feet. The *Anoplotheriidæ* are didactyle in front, and tridactyle behind. The posterior foot has a well-developed second digit directed

more inwards than the others, which it is supposed supported a natatory web. In the Oreodontidæ all the feet are regularly tetradactyle.* The Anoplotheriidæ differ also in the presence of an additional cusp on the inner side of the superior molars, accompanied by an imperfect development of one or both pairs of the internal crescents. In *Anoplotherium* the internal crescents of the inferior molars are incomplete, and more or less represented by tubercles. In the *Oreodontidæ* there are two pairs of fully developed crescents, and no internal tubercles. The details of the structure express various affinities. The axis is intermediate between that of the suilline and ruminant *Artiodactyla;* the other cervicals are suilline, while the remaining vertebræ are ruminant. The scapula is ruminant, not suilline; while the humerus is like nothing but *Anoplotherium.* The radiocarpal articulation is intermediate between that of hogs and ruminants. The unciform supports the lunar bone. The sacrum is ruminant, the ilium suilline. The femur and tarsus are much like those of the peccary.

The genera of this family known to me are the following:

I. Orbit incomplete; last premolars in both jaws with two external crescents or Vs.

Premolars three. ..... *Coloreodon.*
Premolars four ..... *Agriochoerus.*

II. Orbit complete; premolars four, the fourth with one external crescent.

a. No facial vacuities.

Premaxillaries distinct; otic bullæ not inflated. ..... *Oreodon.*
Premaxillaries distinct; otic bullæ inflated. ..... *Eucrotaphus.*
Premaxillaries coössified; otic bullæ inflated. ..... *Merycochoerus.*

aa. Facial vacuities present.

Premaxillaries coössified, dentigerous; vacuities prelachrymal only ..... *Merychyus.*
Incisors six above, persistent; vacuities prelachrymal and prefrontal; nasal bones much reduced ..... *Leptauchenia.*
Incisors very few, caducous; vacuities very large ..... *Cyclopidius.*

III. Inferior premolars three.

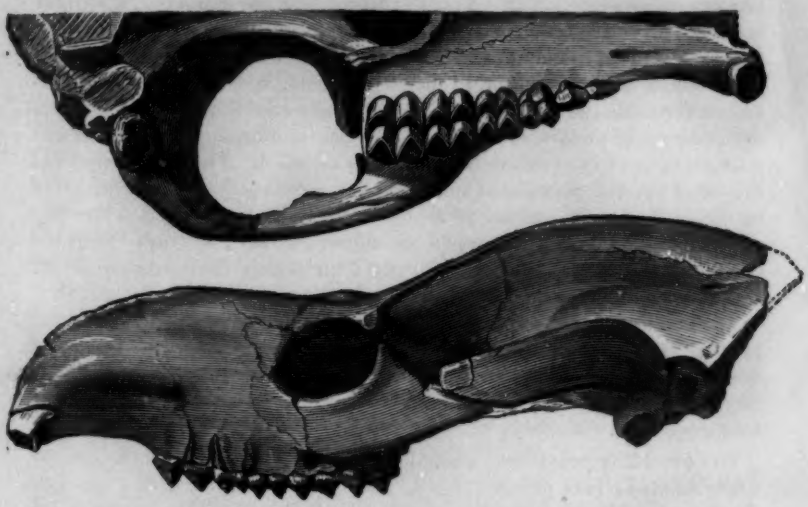
True inferior canine functional; inferior incisors one on each side. *Pithecistes.*

The number of species referred to these genera in the succeeding pages is as follows:

Oreodon	3
Eucrotaphus	3
Merycochœrus	7
Merychyus	6
Leptauchenia	3
Cyclopidius	2
Pithecistes	3
Agriochoerus	6
Coloreodon	2
	35

* I have observed this in the genera Oreodon, Eucrotaphus, Merycochœrus, and Merychyus.

The present paper is chiefly devoted to the proper distinction of these species and genera or cranial characters only. Figures of all will be given in my volume which embraces this subject, in the Report of the U. S. Geological Survey of the Territories.



Chloreodon ferox Cope, one-half natural size. Original; from Report U. S. Geolog. Survey Terrs., vol. iii, F. V. Hayden in charge.

OREODON Leidy.

Proceedings Academy Philadelphia, 1857, p. 238. Ancient Fauna of Nebraska, Smithsonian Contrib. to Knowledge, 1853, p. 29. Extinct Mammalia Dakota and Nebraska, 1869, p. 72. Report U. S. Geological Survey Terrs., 1873, I, p. 201. *Merycoidodon* Leidy, Proceeds. Acad. Philada., 1848, p. 47 (nomen nudum). *Cotylops* Leidy, Loc. cit., 1851, p. 239.

Premaxillary bones distinct from each other. Otic bullæ not inflated. No lachrymal vacuity of the face; nasal bones normal. Premolars four in both jaws.

Dental formula I. $\frac{3}{3}$; C. $\frac{1}{1}$; P-m. $\frac{4}{4}$; M. $\frac{3}{3}$; the series uninterrupted. Crowns of the molars robust, well distinguished from the roots. Grinding surface of the true molars simply selenodont, *i. e.*, with but two pairs of crescents. Superior premolars composed of a single external compressed cusp with crescentic section, and internal cingula or crescent. The fourth premolar with a well developed internal crescent; the first three with rudimental internal crescents in the form of basal cingula. Superior canines distinct. Inferior premolars of two kinds; the first canine-like in form and function; the others consisting of a single external cutting edge rep-

resenting two crescents, of which the anterior has its posterior horn developed as an obliquely transverse crest directed inwards. Last true molar with a heel composed of two columns.

In the superior temporary dentition the last premolar has the form of the first permanent true molar. The third premolar has five lobes, *i. e.*, four crescents and an anterior odd one. The other temporary premolar resembles that of the permanent series. The last inferior temporary premolar has the three pairs of lobes usual in the *Artiodactyla*, and the two which precede it resemble the corresponding permanent teeth. Says Leidy :* "The permanent true molars successively protrude and occupy their functional position before any of the deciduous molars are shed. The displacement of the latter by their permanent successors appears to begin with the eruption of the last of these, which is followed by those in advance. The first permanent premolar of the upper jaw appears to have protruded after the deciduous teeth, and occupied a position with them in the functional series, but remains after these are shed."

The cranial characters which belong to *Oreodon* as a genus are the following : Orbit completed behind ; temporal fossæ separated by a sagittal crest. A lachrymal fossa, but no facial nor frontal vacuities. Premaxillary bones distinct from each other and from the maxillaries. Nasal bones well developed. Auditory bullæ not inflated.

The preceding dental and cranial characters have been pointed out by Leidy in his various palæontological works. On account of the absence of the necessary material he was unable to give the characters of the remaining parts of the skeleton. These are of course necessary to a correct estimate of the affinities of the genus, and I will endeavor to add such information as my material will permit. This consists of numerous more or less complete skeletons found in connection with the skulls by myself in Colorado in 1873.

Vertebræ. The *cervical* vertebræ are rather short, and the character of the articulation of the centra slightly opisthocoelous, and the articular faces are quite oblique. The axis is the longest vertebra ; the three last centra are subequal in length. In one of my series the seven cervicals are preserved. In all of these, excepting the seventh, the bases of the diapophysis are perforated by the vertebrarterial canal. In the sixth vertebra, the decurved parapophyses are especially robust. The axis and three succeeding centra display strong hypapophyses at their posterior extremities, which are carried forwards as strong median keels. The odontoid process is depressed so as to have a lenticular section ; it is not excavated above, but in my largest specimen the internal borders of the facets for the atlas are continued so as to enclose a short groove on each side at its base. In one smaller and immature specimen this is wanting. The vertebrarterial canal of the axis is enclosed as in the other cervicals. The canal for the second spinal nerve has a narrow roof, but there are no canals

* Ancient Fauna of Nebraska, p. 41.

for the succeeding pairs of nerves perforating the neural arches. The atlas is not very elongate. The base of the diapophysis has a perforating canal, which issues in a large inferior fossa. The vertebrarterial canal then perforates the diapophysis upwards anterior to the middle of the base, and then soon enters the neural canal just posterior to the superior margin of the cotylus of the occipital condyle.

The centra succeeding the cervicals increase gradually in length posteriorly. Those of the anterior part of the dorsal series are quite depressed, but the vertical diameter rapidly increases, so as to be equal to the transverse in some of the lumbars. A trace of the opisthocoelous articulation exists throughout the dorsals but is very little marked in the posterior centra. There are no hypapophyses on the dorsals, but on one of them, probably the third, the inferior and lateral faces are separated by a strong angle, which is strongest anteriorly, giving the articular face a subquadrate outline. The rib-bearing diapophyses are robust. On the posterior dorsals the capitular and tubercular surfaces are confluent, forming a narrow facet on the anterior face of the diapophysis, in a manner not seen in *Cervus elaphus* or *Sus scropha*. The centra of the lumbars, after lengthening, become shorter immediately in front of the sacrum. The vertical diameter of one or two posterior ones is less than that of the anterior ones. The greater number of the lumbars display a small compressed hypapophysis at their anterior extremity; but this is wanting on the posterior ones. The neural arches of the dorsal and lumbar vertebræ are nowhere perforated for the spinal nerves.

The lumbar prezygapophyses embrace the articular faces of the posterior ones, which have a section of one side (below), the end (external), and a half the other side (above), of a transverse ellipse. The superior recurved surface does not appear.

The sacrum consists of five vertebræ, with very depressed centra. The ilium is attached to the diapophysis of the first, and a small anterior portion of that of the second. That of the fourth is flat and free. The anterior zygapophysis of the first displays a slight degree of the superior incurvature general in *Artiodactyla*. The caudal vertebræ were numerous, forming a long tail. The proximal ones are moderately depressed, while more distal ones with wide diapophysis and complete neural arch, are subcylindric, and more elongate. The number of vertebræ preserved in the most complete of my specimens, is as follows:

	Cv.	D.	L.	S.	Cd.
O. culbertsoni ad.	7	5	6	4	4
O. culbertsoni juv.	5	8	6	2	1
O. gracilis	4	5	3	*	*
O. g. coloradoënsis	7	8	6	5	3

An anterior, perhaps second, *sternal segment* is flat and subquadrate in outline, with large hæmal articular face of the lateral margin anteriorly, and a small one posteriorly. No inferior carina.

The spine of the *scapula* rises abruptly from the neck as in Ruminantia, and the coracoid process is short and obtuse. The spine continues to the distal extremity, which is regularly convex.

The most perfect *innominata* in my collection are deficient in the symphysis. The form of the ilium is more that of a hog than of a ruminant. The peduncle is even stouter, and the superior border is abruptly expanded below the middle of the length of the bone. The superior and inferior borders are subparallel as in the hog, and not divergent as in the ruminants. The anterior edge is acute, and uninterrupted by an anterior inferior fossa or spine. The pubis is robust and transverse, and without prominent basal pectineal tuberosity. The incisura acetabuli invades the base of the pubis a little, but the ischium more extensively. The obturator foramen is quite large. The distal border of the ischium is obliquely truncated as in many other Artiodactyla, and more nearly resembles that of the peccary than any other recent form I have observed. The tuber proper is a convex edge, not thickened, and its superior edge is continued into a strong up-looking tuberosity. This region is not so robust as in most recent forms.

The *humerus* of *Oreodon* is readily distinguished from that of recent *Artiodactyla* by several peculiarities. The greater tuberosity is large, rising above the head; and is incurved, terminating inwards in an acuminate apex. Its border at the base is thrown into an obtuse angle. The lesser tuberosity is small, and is well separated from the greater by a deep and wide bicipital groove. The deltoid ridge is distinct. The condylar extremity is more transversely extended than in any recent Artiodactyle, owing to the fact the posterior interior distal tuberosity is placed interior to the trochlea instead of partially behind it, and that there is, in addition, an internal epicondyle not seen in the recent suilline or ruminant members of the order. The intercondylar ridge is strong, and wider than in most recent ruminants; in the suillines it has nothing like such a development. Another peculiarity is the flange-like free border of the external trochlea, which is especially recurved at its superior part.

The *radius* is distinct from the ulna throughout. The relation of the ulnar to the radiocarpal surface is posterior as well as exterior; the common suture of the two, making an angle of 45° with the long axis of the radiocarpal surface. The head is a transverse oval, with the inferior face forming a regular curve without notch. Its articular surface is divided into three portions in adaptation to the internal and external humeral trochleæ and the wide median ridge. The external face is beveled forwards above, to fit the flange-like projection of the external trochlea. The shaft of the radius is not very stout, and has a nearly equal transversely oval section to near the distal expansion. Here are wide grooves for the extensor tendons, one superior, the other obliquely exterior. The carpal articular facet has the general ungulate characters. The scaphoid facet is concave above, convex and condyloid below, and is only distinguished from the

lunar facet by a contraction of the anterior and posterior borders. There is no indication of distinguishing ridge between the lunar and cuneiform facets. The posterior border at their junction is prominent, enclosing a fossa with the scaphoid condyle, which does not, however, excavate the intervening surface. The scaphoid condyle is not divided by a ridge.

The *ulna* gradually contracts distally from a robust olecranon. The shaft beyond the humeral cotylus has an oval section, with its long axis forming an angle of 45° to the perpendicular. The olecranon is short and compressed, its posterior border rising nearly as high as the coronoid process. The edges of the humeral cotylus are not flared beyond the shaft.

In the *carpus* the unciform nearly reaches the scaphoid, which is supported by the magnum and trapezium.

The great trochanter of the *femur* is not produced beyond the line of the head, and is well recurved, enclosing a large fossa. The little trochanter is large. The *fossa ligamenti teris* is submedian, subround and large. Distally, the patellar trochlear groove is quite elevated; its lateral crests are of equal prominence, and nearly equal superior prolongation. The patellar groove is continued some distance above the crests, but there is no fossa in this region as in the hog. The popliteal fossa is well marked, and the condyloid articular surfaces are not entirely cut off from the rotular. The external linea aspera terminates first in a rugose muscular insertion, and then in a shallow fossa a short distance above the condyle. There is no crest nor deep fossa. This element is more like the corresponding one in *Dicotyles torquatus* than in any other mammal. The patella is a short wide bone, with a large anteroposterior diameter. One extremity is acute, the opposite one truncate.

The head of the *tibia* is also like that of *Dicotyles*. The spine is divided as usual, and not much elevated; the crest is prominent, but is wide and truncate above at the head. It is not excavated as in *Sus*. The external tendinous notch is well marked. The external margin of the shaft does not display any sutural surface for the fibula. The surface of attachment of an external malleolus is distinct. The internal malleolar process is narrow and is produced well downwards. The anterior intertrochlear angle is prominent; the posterior only convex. The trochleæ are deep, the outer being both the wider and the deeper.

The *astragalus* presents well marked characters. The distal extremity displays the two usual parallel trochleæ, which are separated by a pronounced angle. The cuboid trochlea slopes somewhat backwards, while the navicular is strongly concave. The tibial trochleæ are unequal, the internal being smaller than the external. It is separated from the latter by a constriction which is well rounded and not angulate as in the hog. The external side of the astragalus displays a wide malleolar band, a wide posterior and narrow anterior calcaneal facets, and an undivided concavity intervening between the latter. On the inner side, the malleolar face

descends to below the middle, as in *Hypertragulus*, and there is no vertical nor horizontal distal crest. The inferior calcaneal facet is undivided and not grooved, and does not extend over the internal border of the inferior side of the bone. It exhibits an acute border on the external side. The calcaneum is rather elongate, and the free portion is compressed and with obtuse margins above and below. The transverse astragalar process is not large and is not produced beyond its facet. The ascending plate is well developed and has a superior, uninterrupted convex facet for the fibula, with a narrow facet on its inner side. The inner distal astragalar facet extends the entire length of the cuboid facet. There is a longitudinal ridge on the external side of the distal end of the calcaneum.

The *navicular* and *cuboid* bones are distinct from each other and from the ectocuneiform. The astragalar ligamentous fossa is in the naviculocuboid suture. The inferior proximal angle of the cuboid is produced posteriorly, and the peroneal process well forwards. The ectocuneiform is distinct, and much wider than long. The mesocuneiform is exterioposterior in position, and the transverse diameters are small. It is produced distally, overlapping the head of the second metatarsus. Entocuneiform wanting. The metapodial bones are entirely distinct. The lateral metatarsals are well developed. The second articulates with both the ecto- and mesocuneiform bones, by a proximal extremity which is laterally compressed. The third and fourth are subequal in width, and articulate exclusively with the ectocuneiform and cuboid respectively. The fifth metatarsus is compressed proximally, and the external part of its extremity articulates with a lateral fossa of the cuboid. The distal articular extremities of the metapodials are separated from the anterior face of their shafts by a transverse groove; and they have a well marked articular fossa on each side. The trochlear tongue only exists on the posterior face, where it is prominent and compressed. It disappears on the middle of the distal end, and is wanting on the anterior face. The phalanges are depressed proximally, the penultimate ones distally also. The ungues are rather depressed and have convex external borders. There is a pair of sesamoid bones below the distal articular extremity of the metatarsals.

History. The dental and cranial characters of this genus were fully described by Dr. Leidy in 1852, as already cited. In the Extinct Mammalia of Dakota and Nebraska, published in 1869, Dr. Leidy added the following points in the osteology of the skeleton of the *Oreodontidæ* (p. 72): "What are supposed to be the bones of the forearm and leg are discrete, as in the hog, and the bones of the feet correspond in number with those of this animal." In 1873* Prof. Marsh confirmed these statements so far as regards the metacarpal bones, and added that "the navicular and cuboid bones were loosely coössified or separate." The structure of the vertebræ, and of the greater part of the scapular and pelvic arches,

* Amer. Journ. Sci. Arts, p. 409.

with the carpus, tarsus and feet, with the exceptions above noted, are now described for the first time.

This genus appears first in time in the known history of the family, and presents us with its primitive or least specialized characters, or those nearest the average condition of the ordinary primitive ungulate.

Species. The species of this genus are difficult to discriminate from the evidence of crania alone, and their true number will remain uncertain until we can study entire skeletons. My material enables me to make some progress in this direction. After the removal of the forms with inflated bullæ to the genus *Eucrotaphus*, there remain the two species originally referred to Oreodon by Leidy, the *O. culbertsoni* and the *O. gracilis*. To these Leidy subsequently added two others, the *O. affinis*, which is intermediate in size between the two named, and the *O. hybridus*, of larger size than either. As the condition of the otic bullæ in the last is unknown, its generic reference is not certain. All these forms are from the White River epoch of Dakota, Nebraska and Wyoming.

My material is largely from the White River beds of Colorado. I find from this region the true *O. gracilis* and the *O. culbertsoni*, abundantly represented. Besides these there is a form intermediate between the *O. gracilis* and the *O. affinis*, which is nearer the former than the latter. Of *O. gracilis* there are two skulls complete; of the form next larger, which I call *O. gracilis coloradoënsis*, two complete crania (one with skeleton), and a face with teeth. Of a form between the *O. affinis* and the *O. culbertsoni*, there are four skulls complete (two with skeletons); and of *O. culbertsoni* proper, numerous parts of skulls with teeth, but none complete. No other regions which I have explored have produced these species; not even the Ticholeptus beds, where they might have been reasonably expected to occur.

The distinction of the previously known species will remain as Leidy has left it, with certain reservations in the matter of dimensions; while I add two sub-species.

Nasal bones obtuse posteriorly; frontals little produced on either side of them; true molar teeth not exceeding M. .035 in length; canine and premolars .030; width of front .046. *O. gracilis.*

Nasal bones obtuse posteriorly, frontals little produced on either side of them; true molar teeth not exceeding .037 in length; canine and premolars .039; width of front at middle of orbits .046. ..... *O. coloradoënsis.*

Nasal bones obtuse posteriorly, frontals little produced on either side of them; true molar teeth not exceeding .038; front at orbits .057 in width. ..... *O. affinis.*

Nasal bones acute posteriorly; frontal produced to an acute apex on each side of them; molar teeth .040; front, .056. *O. periculorum.*

Nasals and frontals as last; molar teeth .047; front, .050+.. *O. culbertsoni.*

PROC. AMER. PHILOS. SOC. XXI. 116. 3M. PRINTED JUNE 6, 1884.

From this table it may be seen that the passage from the small *O. gracilis* to the large *O. culbertsoni* is accomplished by a series of intermediate steps. That these extreme forms belong to one species cannot be admitted without evidence of more complete transition than we yet possess. As above remarked, groups of specimens represent each form and adhere to the definitions given with considerable fidelity. The largest of the specimens I refer to, the form *O. periculorum*, however, reaches .042 in the length of the true molar teeth, and the smallest of the *O. culbertsoni* measures .046. These I must consider as sub-species only. As regards the three remaining forms the length of the true molar series shows a complete gradation. The size of the cranium, as indicated by the interorbital width, is in the *O. affinis* as large as that of the *O. culbertsoni* according to Leidy, and the combination of characters presented by this form, would seem to entitle it to specific rank as suggested by Leidy. On the other hand the form *coloradoënsis* agrees in interorbital width with the small *O. gracilis*, differing from it in the greater length of the muzzle and of the cranium. But here, while the proportions of the premolar teeth distinguish the forms well, the length of the brain-case does not coincide exactly with the other measurements. The measurements of four skulls are as follows: *O. gracilis* No. 1, length of skull M. 114.5; No. 2, .130. *O. coloradonĕsis* No. 1, .129; No. 2, .135.

Oreodon gracilis Leidy.

Proceedings Academy Philada., 1851, 239; 1853, 392; 1854, 157; 1857, 89; Owen's Report Geolog. Survey, 1852, 550, Pl. XI, figs. 2–3; Pl. XIII, figs. 5–6. Ancient Fauna Nebraska 1853, p. 53, Pl. V, figs. 3–4; VI, figs. 1–7. Extinct Fauna Dakota and Nebraska, 1869, 94, Pl. VI, figs. 2–3.

Abundant in the White River beds of Dakota, Nebraska, Colorado and Wyoming.

The two sub-species are distinguished as follows:

Length of superior premolar series, M. .023..... *O. g. gracilis*
Length of superior premolar series, M. .029..... *O. g. coloradoënsis.*

Oreodon gracilis gracilis Leidy.

Dakota, Nebraska and Colorado.

Oreodon gracilis coloradoënsis Cope.

Colorado.

Oreodon affinis Leidy.

Extinct Mammalia Dakota and Nebraska, p. 105; Pl. IX, fig. 3.

Probably from the White River beds of Nebraska.

Oreodon culbertsoni Leidy.

Owen's Report Geological Survey, 1852, 548, Pl. X, figs. 4–6; XIII, figs. 3–4; Ancient Fauna Nebraska, Smithsonian Contrib. to Knowledge, 1853, 45; Pl. II, III, IV, figs. 1–5, V, figs. 1–2, VI, figs. 8–11; Proceeds.

Academy Philada., 1853, 392; 1854, 35, 157; 1857, 89; Bronn Lethæa Geognostica, 1856, 930. Extinct Fauna Dakota and Nebraska, 1869, p. 86; Pl. VI, fig. 1; VII fig. 2; IX, figs. 1–3. *Merycoidodon culbertsoni* Leidy, Proceeds. Acad. Phila., 1848, 47, Pl. II; 1850, 121; 1851, 239. *Oreodon priscum* Leidy, Proceed. Phila., Academy 1851, 238; *Cotylops speciosa* Leidy, Ibidem 239; *Oreodon robustum* Leidy, Ibidem 276.

The White River epoch of Dakota, Nebraska, Colorado and Wyoming.

The two sub-species are defined as follows:

Length of superior true molar series from M. .040 to .042. ..... *O. c. periculorum.*

Length of superior true molar series from .046 to .050.... *O. c. culbertsoni.*

Oreodon culbertsoni periculorum Cope.

This smaller race or sub-species has as yet only been found in the White River beds of Colorado and Wyoming. I do not detect any differences between it and the Nebraska form other than those of size. The largest measurement of the *O. c. culbertsoni* given in the above table is derived from Leidy; my largest specimen gives .047 as the length of the true molar series.

Oreodon culbertsoni culbertsoni Leidy.

Very abundant in the White River formation of Dakota, Nebraska, Colorado and Wyoming.

EUCROTAPHUS Leidy.

Proceedings Academy Philada., 1850, p. 92. Ancient Fauna of Nebraska, Smithsonian Contrib. to Knowledge, 1853, p. 56. *Eporeodon* Marsh, Amer. Journ. Sci. Arts, Vol. ix, 1875, p. 249.

Premaxillary bones distinct from each other. Otic bulla swollen. No prelachrymal or nasal vacuities.

This genus presents us with the first step in the series of modifications which the primitive form underwent with the advance of geological time. It appeared contemporaneously with the earliest representatives of the family, *i. e.*, in the White River epoch, but in small numbers. In the succeeding or John Day epoch the genus Oreodon had disappeared, and the present form had multiplied enormously in individuals, if not in species. Subsequent to that epoch it is unknown.

The greater number of the Oreodont remains found in Oregon belong to this genus. The *Eucrotaphus jacksoni* bore the same relation to the Oregon John Day fauna, as the *Oreodon culbertsoni* did to that of the White River epoch.

The species of Eucrotaphus are distinguished as follows:

I. Palatonareal border well posterior to posterior edge of maxillary bones.

a. Infraorbital foramen above front of P-m. iii.

Skull depressed, muzzle short; paroccipital process behind bulla and not separated from it by grooves; bulla grooved to apex for styloid ligament, etc.; zygoma more robust. *E. trigonocephalus.*

II. Palatonareal border in line with posterior edges of maxillary bones.

aa. Infraorbital foramen above posterior part of third premolar.

Paroccipital process behind otic bulla, the internal border of its base opposite that of the bulla. ..... *E. jacksoni.*

Paroccipital process external to the middle of the otic bulla; generally larger. ..... *E. major.*

The name here employed for this genus is the one first given with a definition. The typical species, *E. jacksoni*, was widely distributed, and appears under several varietal forms and sizes, some of which have received names. Subsequently to the original description, Dr. Leidy added to the genus a second species, which probably belongs to the genus Agriochœrus. On this account Leidy inclined at one time to combine the two genera, but afterwards abandoned the idea.

Eucrotaphus trigonocephalus, sp. nov.

This distinct form is only known to me from a single skull of an old animal. In the character of its otic bulla it has resemblance to the species of Agriochœrus, while the maxillary part of the skull has the posterior position of a true Oreodon.

The muzzle is rather depressed, and the premaxillary alveolar border is almost transverse. The position of the canine alveolus is swollen laterally, and between it and the infraorbital foramen the side of the face is slightly concave. The expansion leading to the malar bone commences as the posterior slope of the concavity mentioned, and spreads laterally, without interruption, beginning to project beyond the superior alveolar border at the fourth superior premolar. In the *E. jacksoni* this is not apparent anterior to the first true molar. The top of the muzzle and the front are wider than in that species, and are gently concave in the transverse direction. The anterior temporal ridges are well defined, and concave in outline, uniting early to form a prominent sagittal crest. The malar bone is a little concave below the orbit. The malar process of the maxillary projects downwards in an obtuse angle, opposite the penultimate superior molar. In *E. jacksoni* the malar is convex, and the tuberosity is opposite the last molar. The squamosal process is deeper than in the *E. jacksoni*, and sends a more robust apex into the malar bone, the apex not extending in front of the posterior border of the orbit. The supraoccipital crests are well developed, and project beyond the vertical plane of the condyles; they continue into well marked posttemporal crests, as in the other species of the genus, as well as send an obtuse ridge downwards on each side towards the foramen magnum. The median supraoccipital plane disappears downwards in a wedge-shaped apex, which causes the transverse section

above the foramen magnum to be obtuse angulate instead of broadly flattened as in *E. jacksoni*. The mastoid crests are roughened and are vertical, but do not continue directly into the paroccipital processes, but are separated from them by a deep excavation of the external margin, due to the internal position of the base of the process.

The long diameter of the base of the paroccipital process runs outwards and backwards, and it is attached to the bulla at the middle of the posterior extremity without any intervening grooves such as are seen in the other species of the genus. The bullæ are ovoidal in anteroposterior section, the regularity interrupted, however, by the presence of a ridge on the external side directed posteriorly, enclosing a groove which is continuous with the stylohyoid fossa. The ridge continues into the inferior crest of the tympanic bone. The sphenoid bone is regularly convex in transverse section, while the basioccipital is concave on each side with a narrow median keel, which commences opposite the anterior edge of the paroccipital processes. The basicranial axis is not quite in line with the basifacial, but does not present such an angle with it as is seen in the species of Merycochœrus, where the skull is known to me. In this respect it agrees with the other species of the genus. The postglenoid processes are less prominent than in *E. jacksoni*, but have a base more widely extended outwards. The external border is very oblique, since the apex is narrowed. The glenoid region is more extended, both transversely and anteroposteriorly than in the *E. jacksoni*. The anterior border is continued as an alisphenoid angle which becomes prominent, and overhangs the foramen rotundum. The descending alisphenoid ridge commences within the anterior border of the foramen ovale. The pterygoid angle is anterior to the middle of the palatosphenoid wall of the nareal foramen, and in front of it the edge of the processus pyramidalis is marked by a shallow fossa or mark of insertion of the internal pterygoid muscle. The nareopalatal border is as far posterior to the line connecting the posterior edges of the maxillaries as the width of the second molar tooth. The palate is everywhere nearly flat. The malar bones spread well away from the maxillaries on each side, the anterior border of the zygomatic foramen being a segment of a circle. The squamosal part of the zygoma is more widely expanded than the malar part. In *E. jacksoni* the shape of the zygomatic foramen is quite different. Its anterior outline is interrupted by the projection of the maxillary bone posteriorly, which gives its anterior outline a bilobate form. It is longer than wide in that species, and wider than long in the *E. trigonocephalus*.

The infraorbital foramen is small. There are two lachrymal foramina; one larger, within the preorbital border, the other smaller, below the tuberosity on the rim of the orbit. The frontal foramina are separated by a space equal to one-fourth the entire frontal width. The supraorbital notches are wanting. The preorbital fossæ are well marked, are distinctly defined above, and extend as far as the anterior border of the lachrymal bone. The orbit is round, and looks upwards as well as outwards and

forwards, on account of the prominence of the zygomatic arch. There are two postparietal foramina, one below and behind, the other on the parieto-squamosal suture. The mastoid foramen is not small. The incisive foramina are large, are longer than wide, and are separated by a rather wide isthmus. The palatine foramina are opposite the third premolars. There is a foramen immediately below the postfrontal process. The optic foramen issues posterior to the line of the posterior border of the orbit, and in front of the anteroinferior angle of the alisphenoid. The foramen rotundum is large and round, and is immediately below and within the ridge above mentioned, and is not overhung by a transverse ridge of the same, as in the species of Meryeochœrus known to me. The f. rotundum doubtless includes the f. sphenoörbitale. The f. ovale is smaller and is separated by a considerable interval from the f. lacerum. The latter is subtriangular in form and is rather small, since the base of the otic bulla is in close sutural contact with the sphenoid and basioccipital for a considerable distance. The f. jugulare is subtriangular in outline and is smaller than the f. rotundum. It is entirely distinct from the f. condyloideum, which is the size of the f. ovale. No f. supraglenoideum. In comparing these foramina with those of the *E. jacksoni*, a general resemblance is to be seen. The frontal foramina in that species are *generally* closer together than in *E. trigonocephalus*, and the palatine foramen is *generally* opposite the fourth premolar instead of the third. The foramen magnum is slightly notched on its superior border in both.

The posterior outline of the nasal bones is truncate; it is more or less acuminate in all the specimens of *E. jacksoni* and *E. major* accessible to me. The prolongation of the frontal on either side of the nasals is also short and truncate in this species, and narrow and acuminate in the *E. jacksoni* and *E. major*. The lachrymal is deeper than long; in the species last named it is of variable size and form, but is usually as long as deep. There is no distinct ridge along the parieto-squamosal suture. The alisphenoid has a considerable contact with the pariëtal. The palatomaxillary suture is irregularly convex backwards on each side of the median line. It crosses the palate as in the *E. jacksoni*, at the front of the second maxillary tooth.

The teeth are much worn, and the first and last true molars with several of the premolars have been lost, indicating the age of the animal. The incisors are small and have round roots. The canines are large and of the usual form. The space between them and the first premolar is short. The fourth premolar is small. The second true molar is wider than long, and has no internal cingulum except between the lobes, and has a trace of anterior cingulum.

Measurements.	M.
Axial length from occipital condyles to premaxillary border	.187
Axial length from occipital condyles to postglenoid process	.031

Measurements.	M.
Axial length from occipital condyle to postfrontal process	.076
Axial length from occipital condyle to palatonareal border	.079
Axial length from occipital condyle to end of last molar	.091
Diameters of orbit { vertical	.031
Diameters of orbit { horizontal	.027
Depth malar bone at middle of orbit	.016
" zygomatic process posteriorly to glenoid face	.028
" skull (right angles to profile) at glenoid face	.045
" " " " orbit	.046
" " " " P-m. i	.030
Elevation of occiput from foramen magnum	.044
Width top of muzzle at preorbital fossæ	.040
" at middle of supraorbital border	.059
" " postfrontal process	.075
" " malar below orbit	.110
" " zygomatic process of squamosal	.145
" of occiput at condyles	.066
" " occipital condyles	.039
" " palate at palatonareal foramen	.028
" " " at M. ii	.032
" " " " canines	.030
Length of superior dental series with canines	.088
" " premolar series	.047
" " true molar series	.036
Diameters canine at base { anteroposterior	.009
Diameters canine at base { transverse	.010
Diameters P-m. iv. { anteroposterior	.009
Diameters P-m. iv. { transverse	.013
Diameters M. ii. { anteroposterior	.014
Diameters M. ii. { transverse	.018

The typical specimen of this species was found by Charles H. Sternberg on the North Fork of the John Day river. The horizon is probably somewhat different from that of the true John Day epoch.

Eucrotaphus jacksoni Leidy.

Proceedings Academy Philadelphia, 1850, p. 92. Ancient Fauna of Nebraska, Smithsonian Contributions to Knowledge, 1852, p. 56, Plate VII, figs. 4–6. *Oreodon bullatus* Leidy, Extinct Mamm., Dakota and Nebraska, 1869, p. 106. Report U. S. Geol. Survey, Terrs. 1873, I, p. 318. *Oreodon occidentalis* Marsh, Amer. Journal Sci. Arts, 1873 (May), p. 409. *Eporeodon occidentalis* Marsh, Loc. cit., 1875, p. 250. *Eucrotaphus occidentalis* Cope, Bulletin U. S. Geol. Survey Terrs., V, p. 59.

Comparison of numbers of crania from the White river and John Day

formations fails to reveal any characters distinguishing them as more than one species. In fact the variation in various respects is greater among the individuals of the John Day epoch, than between those of the two epochs. This was by far the most abundant mammal of the John Day epoch while it appears to have been rare during that of the White River.

Specimens differ in the size of the preorbital fossa irrespective of other differences. In some specimens it is wide and profound, including the lachrymal bone; in others it is less extensive and is shallow, involving but part of the lachrymal. It is never wanting or obscure. For estimation of other characters, I select ten crania, nine from Oregon and one from Dakota, as expressing the greatest range of variation. Of these, three display a peculiarity in the form of the otic bulla. Instead of being contracted backwards in front, it is protuberant and full at its inferior anterior part. Five other crania, agreeing with these three in other respects, possess the normal form of bulla. In one cranium, which is rather more robust than the others, the infraorbital foramen is a little posterior to its usual position, being above the anterior part of the fourth premolar. This tooth is also distinctly smaller than in other specimens of otherwise similar dimensions. The majority of specimens range nearly alike in dimensions, but there are forms distinctly larger and smaller, which may represent distinct species. This question can be better decided when the skeletons are known. I give three sub-species which are defined as follows:

Length of cranium M. .197; of molar series M. .086; long diameter of base of paroccipital process transverse; its posterior base flat..... *E. j. jacksoni.*

Length of cranium M. .219; of molar series M. .091; paroccipital process as above..... *E. j. pacificus.*

Length of cranium, M. .235; of molar series, M. .099; paroccipital process strongly compressed, its posterior base angulate on the middle line..... *E. j. leptacanthus.*

The above measurements of length are made from the occipital condyles to the premaxillary border inclusive.

The three forms may represent good species. The *E. j. jacksoni* is of the size of the *Oreodon culbertsoni;* the *E. j. leptacanthus* is larger than the *E. major,* while the *E. j. pacificus* is intermediate between the two.

Eucrotaphus jacksoni jacksoni Leidy.

The typical specimen of the *Oreodon bullatus* Leidy agrees so nearly with the original type of *Eucrotaphus jacksoni,* that I cannot doubt their pertinence to the same species. There are two specimens in the collection of the Philadelphia Academy, besides the last named, and at least one in the museum at Princeton. A specimen from the John Day, Oregon, cannot be distinguished from these. It agrees with Marsh's measurements and description of his *Oreodon occidentalis,* and no doubt represents it. Its

identity with his *O. bullatus* has already been surmised by Leidy (Report U. S. Geol. Survey Terrs., I, p. 318).

Eucrotaphus jacksoni pacificus Cope.

This form is materially larger than the last named, equaling in dimensions and resembling in general form the *Eucrotaphus major* Leidy, of the White River beds. It is no doubt the form which has been identified under that name by Leidy in his report on John Day Fossils in the Report of the U. S. Geological Survey of the Territories, Vol. I. It is different from that animal in the form and position of the paroccipital process, as already pointed out. I have eight crania disengaged from the matrix which agree in dimensions and other characters assigned to this sub-species. In one of them the paroccipital process presents an approach to the form of that of the *E. j. leptacanthus*. A specimen from the White Buttes of Central Dakota agrees with those from Oregon in all the essential characters, and is the second one of the sub-species I have seen which is not Oregonian. I have many crania of this sub-species not yet entirely cleared of matrix.

From John Day river and Crooked river, Oregon; C. H. Sternberg and J. L. Wortman; White river of Nebraska, Mus. Princeton.

Eucrotaphus jacksoni leptacanthus Cope.

This is the largest form of the genus, exceeding the typical *E. major* in the length of the skull by 23 mm. It is thus far represented in my collection by two very perfect crania. There is considerable reason for anticipating that this form will turn out to be a valid species. Besides the peculiar form of the paroccipital processes, the typical specimen presents the following characters:

The frontal region is flatter than in the two other sub-species, and is concave on the median line in transverse section. This concavity is probably partly abnormal. The profile of the sagittal crest instead of presenting a gently convex outline, is concave, rising posteriorly. The lateral occipital crests instead of being angulate are truncate behind, and the inferior angle projects much beyond the vertical line of the occipital condyles. As this part is broken off in most of my specimens of the *E. j. pacificus*, I cannot decide as to its value. The inferior carina of the tympanic bone extends forwards to contact with the internal extremity of the postglenoid process. It does the same in the Oregon specimen of *E. j. jacksoni*, and in the Dakota specimen of the *E. j. pacificus*. In two of the latter, from Oregon, where the part is cleaned, the keel does not extend so far forwards or inwards.

The typical specimen is from the John Day beds of John Day river, Oregon, and was found by Jacob L. Wortman.

Eucrotaphus major Leidy.

Oreodon major Leidy, Ancient Fauna of Nebraska, 1853, p. 55, Pl. IV, fig. 6. Proceedings Academy Philadelphia, 1853, 398; 1856, 164; 1857, 89.

Extinct Mammalia, Dakota and Nebraska, 1869, p. 99, Pl. VII, fig. 1; VIII. *Eporeodon major* Marsh, Am. Journ. Sci. Arts, 1875, p. 250.

I find this species to differ in the external position of the paroccipital process, as related to the otic bulla, from the *E. jacksoni*. I might add that it differs in dimensions from all excepting the *E. jacksoni pacificus*. In the *E. jacksoni* the base of the paroccipital process is in the same line as the interior base of the otic bulla. In the Oregon form of the *E. major* the base of the paroccipital process is much flattened, so as to be transverse, and its internal border is on the external side of the extremity of the large swollen bulla. This species differs also from the *E. jacksoni* in the median vertical carina of the occipital bone above the foramen magnum, a region which is in the *E. jacksoni* broadly flattened. Besides these points I do not notice any divergence from the *E. jacksoni*, with which it agrees in the various characters in which the latter differs from the *E. trigonocephalus*.

The Nebraska and Oregon forms do not agree in all respects. Thus, while the dimensions of the dental series are the same in both, the frontal region is more elongate in the Oregon animal, giving greater length to the skull. The third superior premolar has a somewhat different form in the two. They may then be characterized as follows:

Dental series M. .125; skull .224; third superior premolar, subtriangular.....*E. m. major.*

Dental series M. .125; skull .240; third superior premolar subquadrate.....*E. m. longifrons.*

Eucrotaphus major major Leidy.

Known only as yet from the White River epoch of Nebraska and Dakota.

Eucrotaphus major longifrons Cope.

Known from a single skull from the North Fork of the John Day river, Oregon, found by Charles H. Sternberg. It may be observed here that the Oreodontidæ of this locality are mostly distinct from the species of the John Day river proper.

MERYCOCHŒRUS Leidy.

Report U. S. Geol. Survey Terrs., I, 1873, p. 202. Bettany, Quart. Journ. Geol. Soc. London, 1876, p. 262; Cope, American Naturalist, 1884, p. 281. Leidy, Extinct Mammalia of Dakota and Nebraska, 1869, p. 110 (nomen nudum). Proceedings Academy Philadelphia, 1858, p. 24 (nomen nudum).

As indicated in the analytical table at the head of this article, I can only distinguish this genus from *Eucrotaphus* by the confluence of the premaxillary bones. The position of the external infraorbital foramen cannot be regarded as furnishing generic characters, especially as it displays considerable variation and gradation. Some of the species are in this respect quite identical with species of Merychyus (*M. superbus*), while others

possess the widely different position ascribed to this genus by Leidy. Few if any of the characters given by Mr. Bettany as those of the genus, can be regarded as other than characters common to several of its species. Perhaps the most important of these is the angle formed by the basifacial with the basicranial axis, by which the face is presented as much forwards as upwards. The species present considerable variety in form. The genus embraces the largest species of the family, such as *M. macrostegus*, *M. superbus*, etc. The characters of the species are as follows:

I. Foramen infraorbitale above middle of fourth superior premolar; posterior part of zygoma expanded; palate moderately produced posteriorly.

Squamosal part of zygoma less expanded anteriorly and with rounded border; head elongated; premaxillary bone not produced; otic bulla larger, compressed, extending anterior to postglenoid process; size large ..... *M. superbus.*

Head shortened occipitally, so that a line drawn through postglenoid and paroccipital processes makes 90° with the middle line; malar bone openly grooved below orbit; angle of mandible obliquely truncate. ..... *M. leidyi.*

Squamosal part of zygoma most expanded in front, and elevated behind, so that the cranium is as wide as from the paroccipital process to the canine tooth; its posterior angle rising to a level with the sagittal crest; its inferior edge spread outwards; its superior edge truncated; occiput not shortened; malar flat below orbit; postglenoid process marking front of bulla..... *M. chelydra.*

II. Foramen infraorbitale above the first true molar. Palate greatly produced posteriorly.

Squamosal part of zygoma much expanded, and with truncate edge; malar bone robust, prominent; skull, width equal length from condyles to first premolar; maxillary produced anteriorly; frontal plane, transverse diamond-shaped; bulla small, conical, posterior to anterior edge of postglenoid process..... *M. macrostegus.*

Squamosal part of zygoma little expanded upwards or laterally, edge rounded; malar bone flat; bulla large, extending in front of postglenoid process; front longitudinally diamond-shaped, decurved at orbit..... *M. montanus.*

III. Foramen infraorbitale above anterior border of second true molar.

Zygoma originating above second molar; large; incisors small (fide Leidy). ..... *M. rusticus.*

Zygoma originating above third true molar; larger; incisors large (fide Leidy). ..... *M. proprius.*

Of the above seven species, four are represented in my collection, some of them by a large amount of material. The latter are from the John

Day and Ticholeptus Miocene horizons. The *M. rusticus* of Leidy is only known to me from the descriptions of that author. It is from the Sweetwater river, Wyoming, from a bed of probably Ticholeptus age. The *M. proprius* Leidy, also unknown to me by autopsy, is from the head of the Niobrara river, Nebraska, from a bed said by Hayden to be intermediate between the Oreodon or White River and Procamelus, or Loup Fork horizons, and therefore probably of Ticholeptus age also. The *M. leidyi* I only know from the description of Mr. Bettany. It is from the John Day beds. Mr. Bettany also describes an *M. temporalis*, which I cannot distinguish from the *M. superbus* Leidy.

Merycochœrus superbus Leidy.

Oreodon superbus Leidy, Proceedings Academy Philadelphia, 1870, p. 109. Extinct Mam. fauna, Dakota and Nebraska, 1869, p. 211; Plate I, fig. 1; II, fig. 16; VII, figs. 7–11. *M. temporalis* Bettany, Quar. Journ. Geol. Soc., London, 1876, xxii, p. 269; Pl. XVII.

Of this fine species I have nine crania extracted from the matrix, and a good many not yet cleaned. As the specimen described by Leidy is in a very imperfect condition, the characters of the species, and even its generic position, have remained hitherto very obscure.

As compared with the allied species, the *M. superbus* is slightly exceeded in size by the *M. macrostegus* and *M. montanus*. Its posterior zygomatic expansion is less pronounced than in the *M. macrostegus* and *M. chelydra*, and its border is rounded, even when, as is sometimes the case, it is greatly thickened. In the first and last named of the above species, its border is separated by a distinct angle from both the internal and external faces, forming thus a distinct truncate face which looks upwards. The otic bulla is larger than in the two species mentioned, and extends anterior to the postglenoid process. The nareal fissure extends well down towards the alveolar border of the premaxillaries, which are therefore more extensively separated than Leidy represents to be the case in the *M. rusticus*. The external face of the malar bone below the orbits is flat. The anterior extremity of the zygomatic process is not so prominent as in *M. chelydra*, and is rounded instead of being flared out below, as in that species. The greatest width of the skull is at the glenoid surfaces, and not anterior to them, as in *M. chelydra*. In only one of seven crania, where the parts are preserved, does the posterior squamosal angle rise as high as the sagittal crest.

I cannot detect any difference between the specimen described by Mr. Bettany as the type of his *M. temporalis*, and those of the *M. superbus* in my possession. The shallowness of the preorbital fossa described by Mr. Bettany is repeated in one of my crania, and its depth is very variable in the others. As regards the *M. leidyi* of Bettany, I have none exactly like it, although the type specimen does not differ much from the *M. superbus*, to judge from the figure and description given in the Quarterly Journal of the Geological Society, 1876, p. 270. The two distinctive

characters, which appear most tangible among those mentioned by Mr. Bettany, the shortness of the occipital region, as measured by the angle made by a line drawn through the postglenoid and paroccipital processes, with the middle line, and second, the grooved character of the suborbital part of the malar bone, are not found in any of my specimens of *M. superbus*. The anterior extremity of the squamosal process of the zygoma is protuberant in one of them, as in the *M. leidyi*. Another character is suggested by Mr. Bettany's figure, but is not mentioned in the text. The angular border of the mandibular ramus extends obliquely forwards instead of being prominently convex as in the best preserved entire mandible of the *M. superbus* in my possession. Nevertheless in another specimen, where a good deal of the posterior border is preserved, the outline is nearly as oblique as in the *M. leidyi*. The species, however, is distinct so far as now known.

John Day epoch, Oregon, C. H. Sternberg and J. L. Wortman. Localities, John Day river, Bridge creek, and Camp creek of Crooked river.

Merycochœrus leidyi Bettany.

Quarterly Journal of the Geological Society of London, xxxi, 1875, p. 270; Plate XVIII.

Defined and discussed under the preceding species.

John Day epoch, Oregon; Lord Walsingham. John Day river.

Merycochœrus chelydra, sp. nov.

This species is known to me by a skull without mandible, which is entire, except that the extremity of the nasals and the border of the premaxillary bones are broken off. It is unfortunate that I have no second skull to confirm its characters, but my numerous specimens of the *M. superbus*, to which it is most nearly allied, do not present any approximations which suggest transitions between the two.

The striking character of this cranium is its great breadth at the temporal region, as compared with its length and other dimensions. The forms of the otic bulla differ from those of the *M. superbus*. One method of expressing the width of the skull is as follows. The point of the frontal bone which is equidistant from the supraoccipital notch and the external edge of the zygomatic arch, measured in a horizontal plane, is directly above the posterior or nareal palatal border, when the skull rests on the teeth. In the *M. superbus*, in the most robust examples, this point is above a point which is a good deal nearer to the line of the anterior edge of the glenoid surfaces than to the palatal border, and at least 30mm. posterior to the latter. That this relative shortness of the basicranial axis is not due to a shortening posterior to the glenoid surfaces, as is the case in *M. leidyi* Bett., is proven by the fact that a line drawn through the postglenoid and paroccipital process makes an angle of 90° with the middle line, as in *M. superbus*.

The muzzle is compressed and its superior surface is regularly rounded

The side is divided by the gentle convexity continued forwards from the malar region. Below this and above the premolars the face is concave. Above it the preorbital fossa is well marked, though not deep, and gradually fades out anteriorly. The interorbital region is flat, as in *M. macrostegus*, and the supraorbital border is not decurved, as it is in *M. superbus* and *M. montanus*. The supraorbital and preorbital borders of the front are, however, not continuous as in *M. macrostegus*, though nearly in the same line, which they are not in *M. superbus*. The orbits are more oblique than in *M. superbus*, looking more upwards and forwards, and their vertical exceeds their transverse diameter. The malar bone though oblique, is more vertical than the orbit below the latter, and has an uninterrupted gently concave surface. The postorbital bridge is narrow, and consists one-half of the malar and one-half of the frontal bones. The inferior edge of the malar is thin and is slightly convex downwards, and passes behind the protuberant squamosal at a point behind the line of the postfrontal process. The anterior extremity of the squamosal is not protuberant below the orbit and only begins to rise gradually below the line of the postfrontal process. It then expands rapidly downwards and outwards in a strong curve, with its flat surface looking upwards as much as outwards. After making a short downward turn it rises steeply, contracting gradually inwards, and presenting a convexity posteriorly, with its truncate edge looking outwards. Its apex is nearly on a level with the sagittal crest. The inner or descending edge of this process is concave, so that the apex overhangs a little the posterior outlet of the temporal fossa. The anterior temporal angles are strongly marked and unite into a sagittal crest. The edge of the crest is thickened, so that its section is a letter T.

The supraoccipital bone presents a wide flat convexity above the foramen magnum, in distinction from the stronger convexity of *M. superbus*, and the still stronger of the *M. macrostegus* and *M. montanus*. As in the other species, the posttemporal (= lateral occipital) crests are only present at the upper half of the occiput. Between them there are two ligamentous or tendinous insertions, but no median keel. The exoccipital and posttympanic borders form a tuberosity below the meatus auditorius, which passes upwards into a short convex posttemporal crest. The paroccipital process nearly reaches the postglenoid by its anterior external edge. The tympanic is complete, is not keeled below, and extends itself as a lamina over the posterior side of the postglenoid process. The section of the basioccipital is open V-shaped. The inferior flat surface of the sphenoid is produced backwards in a wedge-shaped prominence to a line connecting the anterior edges of the paroccipital processes. It has the same form in *M. macrostegus*, but in three skulls of *M. superbus*, where it is visible, the apex of the wedge does not extend posterior to the middle of the otic bullæ. The bullæ are small and subconical, and reach as far as the anterior edge of the postglenoid process. In the latter the transverse diameter exceeds the anteroposterior, which exceeds the vertical diameter. This process and the otic bulla are of about equal protuberance. In four

crania of the *M. superbus*, where both are well preserved and exposed, the bulla is considerably more prominent than the postglenoid process. The glenoid surface is well-defined and equally wide at both extremities. The inferiorly presented surface of the zygomatic arch, is wider than in any of the other species, including examples of *M. superbus* of superior dimensions in other respects. The surface is rugose. The length from a line connecting the median external columns of the last superior molar, to the posterior nareal border, enters three times into the distance from the latter to the border of the foramen magnum. In *M. superbus* it goes three to three and a half times; in *M. macrostegus* and *M. montanus* once only. Behind the molars the produced palatal roof is more concave than between the last two true molars. The palate becomes then more concave (convex), and between the first premolars and canines becomes flat, and expands laterally. The nareal fissure is not much contracted between the premaxilliaries.

The infraorbital foramen is above the anterior half of the superior fourth premolar, and is of moderate size. The frontal foramina are separated by a space which is less than half as wide as that which separates each one from the superciliary border. There is no supraorbital notch. The incisive foramina are large, are wider than long, and approach close to the bases of the canine teeth. The palatine foramina are minute or obsolete. The foramen ovale is isolated and is opposite the junction of the glenoid and postglenoid surfaces. The jugular foramen is isolated by the extensive contact of the otic bulla and the basicranial axis. Perhaps the condyloid foramen is included in it, as I do not find it in the usual position. The animal is so old that no sutures are visible.

The teeth are not all cleared from the matrix, which is hard and brittle. The first true molar is much worn. The first premolar is two-rooted, and is separated from the canine by a diastema equal in length to the long diameter of its crown.

Measurements.	M.
Length from occipital condyle to front of canine tooth.	.300
" " " " " postglenoid process.	.041
" " " " " postfrontal process.	.132
" " " " " palatonareal border	.118
" " " " " end of last molar	.146
Diameters of orbit { vertical	.0455
Diameters of orbit { transverse	.039
Depth of malar bone at middle of orbit.	.034
" " zygomatic process to glenoid face behind	.088
Width of top of muzzle at preorbital fossa	.043
" at middle of supraorbital border	.094
" " malar below orbit	.160
" " middle of zygomatic arch	.254
" of occiput at superior crests	050

Measurements.	M.
Elevation of occiput from foramen	.084
Width of occipital condyles	.063
Width of occiput at condyles	.095
Depth of skull at right angles to profile at glenoid face	.095
" " " " " " orbit	.087
" " " " " " P-m 1	.075
Length of superior dental series with canine	.159
" " premolar series	.061
" " true molar series	.065
Diameters M. i { anteroposterior	.0180
Diameters M. i { transverse	.0185
Diameters of canine { anteroposterior	.016
Diameters of canine { transverse	.020
Diameters P-m. ii { anteroposterior	.0155
Diameters P-m. ii { transverse	.090
Width of palate at m. i	.044
" " P-m. i	.057

The typical specimen was found on the John Day river, Oregon, by Mr. J. L. Wortman.

Merycochœrus macrostegus, sp. nov.

I have been able to discover in my collection as yet, but one cranium with entire mandible of this species. The very marked characters of this skull are such that no farther evidence of its reference to a peculiar species is needed. Its affinities, as expressed in the analytical key which accompanies the general discussion of this genus, are with the *M. montanus*. This is shown in the posterior positions of the infraorbital foramen, and of the posterior nares. As peculiar characters may be added the form of the frontal plane and of the otic bulla; also the prolongation of both the premaxillary and supraoccipital regions, and the forms of the zygoma, the angle of the mandible, and the first inferior premolar tooth. The skull reaches a greater length than that of any species, excepting the *M. montanus*, but is not nearly so robust as in the *M. chelydra*, resembling in this respect rather the *M. superbus*.

The muzzle is compressed, and there is a decided concavity just above the second premolar, above which the surface is a little convex. Above the infraorbital foramen, the face is abruptly convex, the convexity sloping upwards to the base of the median ridge formed by the convex nasal bones. Behind this the side of the face is a plane which slopes outwards as it descends, which is only interrupted by the rather small, but well defined, preorbital fossa. The fossa is better defined in front than in the other species, but I do not know whether the character is constant. The front is a transverse diamond-shaped area, bounded posteriorly by the anterior temporal ridges, and anteriorly by the lines of the supraorbital borders

produced to their point of intersection with each other. Such point of intersection is above the second true molar in this species; in *M. superbus* and *M. chelydra* it is above the posterior part of the second premolar. The area in these species enclosed by the lines in question is half as long again as wide, instead of wider than long by 18mm. This difference is partly caused by the greater prominence and flatness of the postorbital angle of the frontal bone in the *M. macrostegus*, and the more anterior direction of the orbits, which I may add have none of the tendency to superior direction seen in *M. chelydra*. The wide triangular area thus enclosed on its external sides by the orbit and anterior temporal ridges, is perfectly flat. Such an area can hardly be defined in the other species, and the surface there is rounded and descending. The malar bone is deep, flat and a little oblique outwards, and the rim of the orbit projects a little, giving it a slight concavity. The orbit is deeper than wide. The anterior part of the zygomatic process of the squamosal is not protuberant below the orbit, but gradually rises outwards posteriorly, attaining its greatest expansion opposite the middle of the zygomatic foramen; above, its course is for a time parallel with the middle line of the skull. The form of the zygomatic arch is more like that of *M. chelydra* than any other species, but it is not so much expanded, especially anteriorly. Its inferior and posterior surface is, however, widened, making an angle with the external or marginal surface, which is in turn separated by an angle from the superior and anterior surface; at the middle of the arch the superior surface has a width of 19mm., and the external a width of 23mm. The posterior angle rises to the plane of the summit of the sagittal crest, and the apex, which is less than a right angle, stands above the external base of the postglenoid process. The preglenoid border is not exactly at right angles with the middle line, but makes a slight angle outwards and forwards. The long diameter of the zygomatic foramen is parallel with it. The ridge along the pariëtosquamosal suture is insignificent. The supraoccipital region is very prominent, and as in the other species of this genus is narrowed below by the disappearance of the posterior temporal or exoccipital crests. They are continued downwards and disappear, leaving a wide convex surface above the foramen magnum. This is separated by the usual lateral fossa from the posterior temporal angles.

The coössified mastoid and paroccipital processes much contract the auricular fossa below, but do not close it. The latter is contracted at the base of its terminal part, and is distally slender. The otic bulla is the smallest known in the genus, it is compressed and oval, and not produced beyond the postglenoid processes either forwards, backwards or downwards, in this differing much from the *M. montanus*. It is separated by wide and equal intervals from this process, the glenoid surface, and the basisphenoid. It sends a process backwards and inwards to a sutural junction with the basioccipital bone. The tympanic bone is flat below, and is united with the posterior base of the squamosal by a flat expansion. The postglenoid process is robust, and has the height and thickness equal,

while the width exceeds both. The basioccipital bone is prominently keeled on the middle line, so that the section is a V of a more compressed character than the section of the same in *M. superbus*. The median plane of the sphenoid is prominent, and is continued as a wedge with the apex opposite the posterior borders of the otic bullæ. The palatine borders are parallel, except where they form on each side an open angle at the junction of the descending process of the sphenoid, which is here directed forwards. Its external border is distinct from that of the palatopterygoid plate, and makes a groove with it. The maxillary bone is not produced posterior to the notch on either side of the base of the posterior production of the palatine bones. The middle line of the latter is deeply concave opposite the former, and the palate is also especially concave between the first true molars. The palate is flat between the first and second premolars. The inferior surface of the squamosal process of the zygoma is roughened for the origin of the masseter muscle. The inferior edge of the malar comes from its inner side, and is narrow and with a median groove. Its inferior edge is continued as a ridge of the maxillary as far as opposite the anterior lobe of the second true molar. The maxillary bones are more produced anteriorly than in any of the other species. The apex of the nasal bones stands above the posterior border of the canine in this species; above the anterior edge in *M. superbus*, *M. chelydra* and *M. leidyi* (fide Bettany). The posterior border of the nares is above the anterior part of the first premolar in the three species named, except *M. chelydra* where it is over the posterior edge of the canine: in *M. macrostegus* it is above the posterior edge of the longer first premolar.

The infraorbital foramen is large, and its posterior border is above the anterior root of the first true molar. The incisive foramina are large, and each one is a little longer than wide. The nareal opening contracts gradually to its inferior apex. There is a considerable maxillary foramen opposite the middle of the fourth superior premolars. The posterior nareal is not large; its anterior outline is regularly concave. Its lateral (sphenoid) borders reach to opposite the anterior faces of the postglenoid processes and bound the foramen ovale on the inner side. The latter is round, is rather small, and is opposite the middle of the postglenoid surfaces. The foramen rotundum on the other hand is large and vertically oval, and is bounded below by a transverse prominence of the base of the alisphenoid bone. It probably includes the sphenoörbital foramen, a foramen anterior to its inferior border probably communicating with the nareal chamber. The optic foramen is small, and is situated opposite the anterior two-fifths of the zygomatic fossa and a little above the line of the apex of the foramen ovale. The foramen lacerum is ovoid and not large. The posterior foramen lacerum is a transverse sigmoid, one extremity being the jugular foramen. The mastoid and postparietal foramina are of moderate and equal sizes. No postsquamosal or supra- or postglenoid foramina.

The animal described is too old to exhibit sutures.

The mandible possesses some distinctive characters. The angular border is not prominent posteriorly, extends forwards below, and projects below the general level of the inferior border of the ramus. Neither of these characters is observable in the only ramus of the *M. superbus* in which the lower part of this border is well preserved, but in some others of that species the superior part of the border is much as in *M. macrostegus*. The inferior edge of the ramus is straight, but there is a descending tuberosity of the symphysis which may be an individual peculiarity. The symphysis is very concave in profile, and the incisive border is produced in accordance with the prolonged muzzle. In the *M. superbus* it is sometimes convex, sometimes a little concave, but not so much so as in this jaw. The coronoid processes are small and slightly everted. The inner ridge of its anterior base is more prominent than the exterior, and encloses a fossa with it. The masseteric fossa is not noticeable. There is one large mental foramen below the third premolar. The dental foramen is large and oval, and when the mandible stands on a level surface is opposite the middle lobe of the third inferior molar tooth.

In dentition this species is distinguished by the relatively large size of the premolar teeth, of which the first, second and third are two-rooted in both jaws. Both the first and second in the upper jaw have short diastemata anterior and posterior to them, the largest being behind the canine tooth, and nearly as long as the premolar's crown. All the teeth are a good deal worn in the specimen. One can see two internal cingula inclosing fossæ on the third premolar. The true molars increase in size rapidly posteriorly and the third has a well-developed external heel. The molars have no internal cingula; these are present in five of seven skulls of the *M. superbus* where these parts are cleaned. The most noteworthy point in the mandibular dentition is a very rudimental character of the internal vertical ridge of the crown of the first premolar. The posterior fossa of the fourth premolar is closed, and the anterior remains open, on wearing. In *M. superbus* both are closed in the specimen where visible. The anterior inner wall is represented in the second and third premolars by a cingulum. No cingula on the true molars. First premolar very robust, its section lenticular.

Measurements.	M.
Axial length from occipital condyles* to premaxillary border	.345
Axial length from occipital condyles to postglenoid process	.045
Axial length from occipital condyles to postfrontal process	.138
Axial length from occipital condyles to palatonareal border	.100

*The occipital condyles are broken off in the specimen, so I measure from the superior border of the foramen magnum, which is, in the other species, in the vertical line of the occipital condyles.

Measurements.	M.
Axial length from occipital condyles to end of last molar	.058
Diameters of orbit { vertical	.044
Diameters of orbit { transverse	.036
Depth malar bone at middle of orbit	.037
" zygomatic process to glenoid face behind	.077
" skull (right angles to profile) at glenoid face	.088
" " " " " " orbit	.088
" " " " " " P-m. i	.068
Elevation of occiput from foramen magnum	.084
Width top of muzzle at preorbital fossa	.038
" at middle supraorbital border	.109
" " postfrontal process	.137
" " malar below orbit	.166
" " middle of zygomatic arch	.243
" of occiput at superior crests	.050
" " " condyles	.101
Length superior dental series, with canine	.177
" " premolar series	.092
" " true molar series	.083
Diameters canine { anteroposterior	.013
Diameters canine { transverse	.018
Diameters P-m. i { anteroposterior	.017
Diameters P-m. i { transverse	.075
Diameters m. i { anteroposterior	.019
Diameters m. i { transverse	.0215
Diameters m. iii { anteroposterior	.038
Diameters m. iii { transverse (at middle column)	.029
Width of palate at P-m. i	.061
" " m. i	.053
" " middle of zygomatic arch	.047
Length of inferior dental series with canine	.179
" " premolar series	.088
" " true molar series	.088
" of ramus to posterior edge	.279
Depth of ramus mandibuli at condyle	.124
" " " m. iii posteriorly	.073
" " " m. i posteriorly	.048
" " " P-m. i (front)	.015
Diameters inferior P-m. i { anteroposterior	.019
Diameters inferior P-m. i { transverse	.0125
Diameters " P-m. iv { anteroposterior	.021
Diameters " P-m. iv { transverse	.013
Diameters " m. i { anteroposterior	.020
Diameters " m. i { transverse	.014

Measurements.		M.
Diameters inferior m. iii	anteroposterior	.044
	transverse	.018

This fine species is from the John Day epoch of the Miocene. The typical specimen was found by my assistant, Charles H. Sternberg, on Bridge creek, Oregon. Much credit is due Mr. Sternberg for his unwearied exertions in the cause of science, which have been continued through many occasions of risk and discomfort.

Merycochœrus montanus, sp. nov.

This large animal is represented in my collection by a nearly entire skull with parts of both mandibular rami complete. Rami of another individual give the entire dentition of the lower jaw except the incisors. A third individual is represented by a symphysis with premolars, canines and incisors, and by various parts of the skeleton, including feet. Of the cranium mentioned, the muzzle to the preorbital fossa and the palate to the first true molar are wanting. The region of the larmier is lost, but the general resemblance of the species to the *M. macrostegus* in other respects, leads me to suspect that it is absent, and that the *M. montanus*, is rightly referred to the genus Merycochœrus. This course is indicated by the structure of the superior molar teeth, which have the character of those of this genus, rather than that found in Merychyus. That is, the posterior internal crescent sends its anterior horn to the external wall of the crown, thus cutting off the posterior horn of the anterior crescent. Dr. Leidy has shown that the reverse is the case in the *Merychyus major*; that is that the posterior horn of the anterior crescent reaches the external wall of the crown, cutting off the anterior horn of the posterior crescent. I have observed that this is also the case in the other species of Merychyus which have come under my notice.

The posterior position of the infraorbital foramen and the greatly produced palate distinguish this species from those of the John Day epoch, excepting the *M. macrostegus*, while in the *M. rusticus* and *M. proprius*, the infraorbital foramen is still further posterior. The palate of these species is unfortunately unknown.

The part of the maxillary bone posterior to the infraorbital foramen is nearly flat, and the proximal part of the malar bone is also flat. The inferior edge of the latter is narrow and is marked by a groove which terminates anteriorly in a shallow fossa. The ridge continuous with this edge terminates above the anterior lobe of the second true molar. The zygoma as far as the anterior border of the glenoid cavity is slender, and not convex, but flat in every direction, nor is it decurved as in *M. superbus*. The zygomatic foramen is relatively much smaller than in that species. Its posterior or preglenoid boundary is not at right angles to the sagittal crest as in that species, but is oblique outwards and forwards at an open angle. The obtuse median edge of the zygoma looks upwards, not outwards as it does in *M. superbus* and *M. macrostegus*, and the superior expansion is

opposite the internal extremity of the glenoid face, instead of the external as in *M. superbus*, or the middle, as in *M. macrostegus*. The border descending to the supraauricular crest is thin and vertical in direction, and the superior angle stands above the middle of the postglenoid process, not external to it, as in the two species above named. The postglenoid process is robust and has a convex posterior face. The paroccipital process is long and acuminate. An external truncate ridge on the front of its base partially embraces the meatus auditorius, and curving forwards becomes the anterior edge of the process, which is separated from the postglenoid by but a narrow interval. The tympanic bone forms a tube more distinct from the surrounding regions than in the other species here described, and has a longitudinal inferior keel, which is not visible in the *M. superbus* and *M. macrostegus*. It is separated at the meatus by but a short interval from the base of the postglenoid process. The supraauricular and mastoid crests unite and form a short acute crest, which does not continue into a prominent posttemporal, but descends into a mere angle, which continues as a fine line to the convexity of the true posttemporal crest above. The latter arises from the bifurcation of the sagittal crest, and after a strong convexity descends with its fellow to a narrow prominent convex ridge, which rises from the foramen magnum. Thus the occiput on either side of this prominent middle line is deeply excavated, and the fossa is bounded on each side and anteriorly by the low posttemporal angle, and the more prominent mastoid ridge. There is no median keel. The median ridge of the occiput is more prominent and not so flat as in *M. superbus*, but is more as in *M. macrostegus*. The sagittal crest is well developed, and has a straight superior border, which is not thickened as in *M. chelydra*. The anterior temporal ridges are represented by an angle which is nearly right. The superior squamosal suture is marked by a prominent ridge. The front is gently convex transversely, and the supraorbital border is more strongly decurved than in *M. superbus*, which are more so than in *M. macrostegus*.

The basicranial axis makes a strong angle with the basifacial as in the other species of the genus, showing that the face was presented obliquely forwards, as in the peccary. The section of the basioccipital bone between the paroccipital processes is V-shaped, owing to the presence of a strong median angle. In *M. macrostegus* this bone is similar, but in *M. superbus* it is much flatter, and there is a weak median keel. The sphenoid is in line with the occipital and has a broadly rounded-truncate inferior face. The otic bullæ are large and compressed. They extend from the middle of the base of the paroccipital process to considerably in advance of the postglenoid process, and approach very near to the glenoid surface. The interval which separates them is small, equaling one-fifth the anteroposterior diameter of the bulla. This is very different from the *M. macrostegus*, where the space between the glenoid surface and the bulla, is equal to the anteroposterior diameter of the latter near the middle. As already pointed out, this species agrees with the species just named in the

great prolongation of the palatal floor of the nareal cavities. The distance from the foramen magnum to the nareal border equals the distance from the latter to the line connecting the median external vertical crests of the last superior molars. In *M. superbus* the former measurement is two and one-half times as great as the latter.

The mandible shows the nearer relationship to the *M. macrostegus* than to the *M. superbus*, in the anterior elongation and greater relative size of the premolar teeth. It agrees with the former in having the profile of the symphysis concave, and not convex as in *M. superbus*. It is less concave in my single specimen than in that of *M. macrostegus*. The position of the posterior extremity of the symphysis is below the middle of the third inferior premolar. The coronoid process is low, and of small size. Its compressed convex apex is directed at an angle of 45° from the middle line outwards and forwards. Its anterior face soon widens out and the internal edge becomes much more prominent than the external, with which it encloses a shallow, subtriangular, subvertical fossa. The external border is continuous with the external alveolar border. The masseteric fossa is small and has no distinct inferior border, and does not descend below the level of the line of the middle molar teeth. The inferior border of the ramus is nearly straight. The inferior incisive alveolar border is much more strongly convex than in the *M. superbus*. The condyle has the posterior articular face on the inner side, as in other species.

The infraorbital foramen is large and is above the anterior part of the first true molar tooth. The meatus auditorius is small. There are two postparietal foramina on the pariëtosquamosal suture. No supraglenoid or postglenoid foramina. There are two mental foramina, one not small below the anterior part of the first true molar, the other, quite large, below the posterior part of the third premolar. The dental foramen is situated on a level with the alveolar border and well posteriorly, its anterior border being a little in front of a line dropped vertically from the apex of the coronoid process. It is thus similar in position to that of *M. macrostegus* and different from that of *M. superbus*, where it is above the line of the apices of the molars, and is posterior to the line dropped from the apex of the coronoid.

In the superior true molars, the size increases rapidly posteriorly. The third is relatively of more elongate form than the first, but the posterior external column is but little produced. The other vertical ridges are quite prominent. The external faces of the external lobes are nearly flat. Besides the relation of the adjacent horns of the internal crescents already mentioned, the posterior horn of the posterior crescent in the first and second molars is cut off from the external wall of its own crown by the anterior horn of the anterior crescent of the crown next posterior. This does not exist in worn molars of *M. superbus* and *M. macrostegus*, but is observable in little worn teeth of the former. It does not look as though the character would disappear with wear in the *M. montanus*. The only

trace of cingulum on the superior molars is on the inner base of the anterior lobe, where it is weak, and in the interspace between the internal lobes, where it is a narrow tubercle. Enamel obsoletely vertically striate. It is wanting on the external side of the internal crescent, as Leidy has shown to be the case in certain species of Merychyus. The fifth lobe of the last inferior molar is well developed and has its two crescents separated by a groove. The adjacent horns of the external crescents are of about equal length. No cingula, except a trace on front and rear of crowns, and a tubercle between the bases of the external lobes. The fourth premolar has two fossæ isolated, one anterior to and the other posterior to the principal apex, which is double, and anterior to the middle. Before wear, each of these fossæ opens inwards. The crown of the third premolar has its inner face unequally divided by a crest behind the middle. Posterior to this the space is occupied on the inner side by two shallow fossæ of which the posterior is the narrower. Anterior part of inner face of crown concave. One principal angular cusp. The second premolar has a compressed triangular crown with a long base, and a weak vertical ridge on the internal side. The first premolar is a very robust tooth with a straight posterior border directed at 95° forwards, and is vertically truncate in the specimen by friction with the canine. Section of crown lenticular, rounded in front.

Measurements.	M.
No. 1.	
Length from occipital condyle to postglenoid process	.049
" " " " " postfrontal process	.135
Width of occiput at posttemporal crests	.054
" " " condyles	.102
Elevation of occiput above foramen magnum	.084
Length from foramen magnum to palatal border	.060
Width between apices of otic bullæ	.042
Length from inferior m. iii to apex of coronoid process	.075
" of superior true molar series	.084
Diameters m. i { anteroposterior	.026
{ transverse (at middle rib)	.025
Diameters m. iii { anteroposterior	.034
{ transverse (at middle rib)	.025
Length of inferior true molar series	.085
Diameters P-m. iv { anteroposterior	.0205
{ transverse behind	.015
Diameters m. i { anteroposterior	.023
{ transverse	.016
Diameters m. iii { anteroposterior	.040
{ transverse	.022
No. 2.	
Length of ramus mandibuli from incisive border to condyle (oblique)	.380

Measurements.	M.
Length of dental series (straight line)	.191
" from last molar to apex of coronoid	.0735
" of premolar series	.085
" " true molar series	.084
" " second premolar on base	.021
" " first premolar on base	.0225
Depth of ramus at coronoid	.044
" " " end of m. iii	.073
" " " middle m. i.	.056
" " " P-m. i. vertically	.034

The specimens of this species were found by Mr. J. C. Isaac in the Ticholeptus beds of Deep river, Montana, during his Expedition of 1880.

Merycochœrus rusticus Leidy.

Report U. S. Geological Survey Terrs., 1873, i, p. 199, Pl. III, figs. 1–3; VII, figs. 1–5; XX, figs. 9–81. Proceedings Academy Philadelphia, 1870, 109.

The smallest species, characterized among other things by the closure of that part of the nareal fissure which separates the premaxillary bones below. According to Leidy's figure above quoted, the depth of the middle line of the undivided premaxillary is greater than the width of the bone, a state of things not approached by any of the species of this genus described in the preceding pages. The premaxillary in the *M. proprius* is not described.

From the ? Ticholeptus beds of the Sweetwater river, Wyoming.

Merycochœrus proprius Leidy.

Proceedings Academy Philadelphia, 1858, p. 24; Extinct Mammalia Dakota and Nebraska 1869, p. 110; Pl. X.

This large species represents the extreme form of the genus in the anterior position of its dental series as compared with the braincase. The zygomatic arch and infraorbital foramen are therefore more posteriorly placed than in any other species. The premaxillary bone is more prominent than in any other, and the incisor teeth have relatively larger dimensions. The size is about that of the *M. superbus*. I have not seen any other than the typical specimen.

From the Ticholeptus beds at the head waters of the Niobrara river, Nebraska.

MERYCHYUS Leidy.

Proceedings Academy Philad'a, 1858, p. 24, (nomen nudum). Extinct Mammalia Dakota and Nebraska, 1869, 115. Report U. S. Geological Survey Terrs. i, 1873, p. 202. Cope, American Naturalist, 1884, p. 281. *Ticholeptus* Cope, Bulletin U. S. Geolog. Survey Terrs., 1878, p. 380.

Premaxillary bones coössified; otic bulla swollen; a vacuity between

the maxillary, lachrymal, and nasal bones, or larmier. Nasal bones normal. First inferior premolar caniniform.

This genus has not been defined prior to the present article, although some characters common to the species of the genus known to him, have been given by Leidy. As now defined it is identical with genus *Tycholeptus* Cope. This group was distinguished by the presence of a larmier, a character whose presence in the species of Merychyus has been hitherto unknown. It is not yet reported indeed as present in any of the original species of the latter, but I think that there can be no reasonable doubt of its presence there. A character found by Leidy in the *M. major* I find to be present in one or more of the superior molar teeth in all the species. The posterior horn of the anterior internal crescent cuts off the adjacent or anterior horn of the posterior internal crescent from contact with the inner side of the external wall of the crown. It is the anterior horn of the posterior internal crescent which reaches the external wall, in the genera Merycochœrus, Eucrotaphus and Oreoden. In Leptauchenia the arrangement is generally as in Merychyus; see under the head of that genus.

This genus is confined to the Upper Miocene beds, the Ticholeptus and Loup Fork epochs. In size the species range from medium to large, the *M. major* equaling any species of the family in dimensions. They are distinguished as follows:

I. True molar teeth not prismatic.

Infraorbital foramen above fourth premolar; malar bone shallow; squamosal with superior zygomatic angle anterior; true molars M. .042 ..... *M. pariogonus.*

II. True molar teeth more or less prismatic.

a. Infraorbital foramen above third premolar.

Larmier a slit; front narrow ..... *M. arenarum leptorhynchus.*

aa. Infraorbital foramen above fourth premolar.

β. Zygomatic arch vertical, and with posterior angle small and rounded.

Larmier triangular; front wide; true molar series M. .044; face convex ..... *M. arenarum arenarum.*

ββ. Zygomatic arch expanded horizontally; posterior angle strong, acute.

Larmier large; true molars .051 ..... *M. zygomaticus.*

ββ. Zygomatic arch unknown.

Facial plate generally concave; true molars M. .045 ..... *M. elegans.*
True (inferior) molars, M. .069 ..... *M. medius.*
True (superior) molars (m. iii inferred), M. .095 ..... *M. major.*

Of the above species, the *M. arenarum* and *M. zygomaticus* are known from entire skulls. In the first named, the foramen infraorbitale appears to be partly above the posterior edge of the third premolar, as well as above the anterior edge of the fourth.

Merychyus arenarum Cope, sp. nov. Sub-species **leptorhynchus** Cope.

This species is represented by a skull which lacks of completeness only the extremity of the muzzle and the angles of the lower jaw. Its size is about that of the *Oreodon culbertsoni* or of the *Merychyus elegans*. The confluence of the premaxillary bones shows that the place of the species is with the last-named genus, and the sigmoid flexure of the masticating line of the superior dentition is a point of resemblance to the species of the same. The position of the external infraorbital foramen is one degree further posterior than in the species of Oreodon, and agrees with the position in two other species of Merychyus (*M. arenarum* and *M. pariogonus*), which is more anterior than in the other species of the genus. The foramen is in fact quite identical in position with that seen in most of the species of Eucrotaphus, to which genus the above named species must be regarded as the nearest in the genus to which they belong.

As in other species of the genus, the malar bone is deeper and less prominent laterally than in those of Oreodon. The preorbital fossa is wider and shallower. The orbit is closed behind.

The premaxillaries are convex in every direction, least so transversly. The fissure which separates them is quite narrow, and is separated from the alveolar border by a rather narrow isthmus of uninterrupted bone. At the canine tooth the direction of the surface becomes longitudinal by an abrupt turn, and the side of the face above the second premolar is uninterruptedly gently concave. The lateral convexity which bounds the preorbital fossa below, appears above the third superior premolar, and becomes more prominent posteriorly as it passes into the flat surface of the malar bone. The anterior orbital border is prominent and thin, and does not develop a distinct tubercle, although its edge is roughened. The profile of the muzzle is a straight line descending gently from the interorbital region. Above the middle of the orbits the frontal bones are gently convex; on the line of their anterior border, there is a concavity of the median line. The superior face of the nasal bones is flat, and is peculiarly narrowed, especially posteriorly, where the large preorbital fossæ approach each other.

The anterior temporal ridges are well marked, and after a gradual approach unite into a sagittal crest, which has a gently convex rising profile. After the posterior bifurcation of the latter, the convex posterior temporal crests do not project beyond the occipital condyles when the inferior edge of the lower jaw rests on a horizontal plane, as in so many other species of this genus and of its allies. These crests continue without interruption above the auricular meatus to the posterior base of the postglenoid process. As compared with the *Oreodon culbertsoni*, the postorbital part of the cranium is short; it is also shorter than in any other species of Merychyus. Thus the length from the posterior border of the orbit to the convexity of the

posterior temporal crest, is as long as from the former point to the anterior base of the first premolar. In the *Oreodon culbertsoni*, the same measurement is equal to the length from the same point to the anterior base of the third incisor. This shortening posterior to the orbit is seen to involve the zygomatic fossa as well as the region posterior to it. Thus the horizontal diameter of the orbit in the *M. leptorhynchus* is exactly equal to the distance between the posterior border of the same and the anterior edge of the glenoid cavity. The posterior part of the superior edge of the squamosal zygomatic process is thin and strongly convex. The apex of the convexity is above a point just anterior to the posterior border of the glenoid cavity. The posterior edge of the process is nearly vertical, and if continued would reach the middle of the base of the postglenoid process. The latter is compressed and rather elongate, and its convex edge has considerable transverse extent. The paroccipital process is long and is flat on its posterior face. The postorbital process of the frontal is elongate wedge-shaped, with its truncate apex below joining a slight elevation of the malar bone, which is much less prominent than in *Oreodon culbertsoni*. It presents an angle outwards and forwards, as the orbital border. The anterior half of the zygomatic process of the malar bone is rounded-truncate below. The glenoid surface is plane transversely, and slightly convex, rising backwards, anteroposteriorly. The anterior border of the squamosal bone is not developed into a ridge.

The frontal bone extends forwards on either side of the nasals, forming a narrow process above the lachrymal bones. It overlaps the superior edge of the maxillary, of which a narrow splint appears between it and the nasal. The nasals are rather narrow, and each has the posterior border rounded. The latter fall above the middle of the first true molar tooth when the inferior edge of the mandible is horizontal. The lachrymal bone has greater anteroposterior than vertical diameter, extending nearly to the line of the infraorbital foramen, or much in advance of its position in *Oreodon culbertsoni*, *Eucrotaphus jacksoni*, or *Merycochœrus superbus*. The malar bone has a correspondingly large anterior extension, reaching to above the posterior part of the fourth premolar. It does not extend so far in the three species just named. The zygomatic process of the squamosal is more deeply received into the malar bone than in any of the three species mentioned, reaching to below the posterior third of the orbit.

The larmier in this species is small, and its anteroposterior diameter is more than twice as long as the vertical. More than half of its inferior border is formed by the maxillary bone. As it is exhibited in the specimen, its superior border is formed by the ascending process of the maxillary bone; whether this is overlapped by the laminar process of the frontal so as to bound the foramen, when in a perfect condition, is uncertain. The posterior edge of the larmier is the lachrymal bone. The external *foramen infraorbitale* is on one side double. The supraorbital foramina form notches at the anterior edge of the supraorbital border. The frontal

foramina are well separated from each other, as in the species of Merycochœrus. The space between them is about equal to that between each one and the superciliary border. There is a large postparietal foramen near the parieto-squamosal suture. If the supraglenoid foramen be present it is not distinguishable in the specimen. The orbit is rounded subquadrate, with the inferior anterior angle a little produced.

The ascending process of the mandible is relatively elevated. The horizontal ramus narrows rapidly anteriorly, and the symphysis mandibuli is produced so as to rise at a very low angle. The alveolar portion is horizontal.

The superior incisors are small and their apices are but little expanded, the external the most so. They are directed vertically downwards. The superior canine is quite small; its crown exceeds in length that of the first premolar by but little, and is directed a little posteriorly as well as downwards. The roots of the first premolar are not as well distinguished as in many other species, and are united in their extra-alveolar part at least. The same is true of the second premolar. The apex of the cutting edge is in line with the anterior border of the crown; the rest of the edge rises obliquely backwards. In the third premolar there is a slight bevel in front of the apex, which is much better developed on the fourth. These teeth are more truncate than the corresponding ones of the species of Oreodon and Eucrotaphus, and the larger species of Merycochœrus. The external faces of P-m. i and ii are convex; that of P-m. iv is concave, but without the reverted vertical borders seen in *Oreodon culbertsoni*. The first true molar has long roots and a short crown. The last two molars have crowns of a more elongate character, with well developed anterior and middle ridges. The latter are not so prominent as those of the molars of the *Merychyus zygomaticus*.

The inferior incisors are directed upwards at an angle of about 30°. They are similar and closely packed. The inferior canine is in close contact with the third incisor, from which it differs in its larger, leaf-shaped crown. The inferior first premolar is a slender one-rooted caniniform tooth, with narrow crown and acute apex. The second premolar is one-rooted, and has a leaf-shaped crown, with acute-angled apex. The third is two-rooted, and has a wider and nearly symmetrical crown. The fourth is much larger, and its elongate crown laps inside of that of the third. Its low angular apex is median. The last inferior true molar is disproportionately larger than the others. No external cingula.

Measurements of Skull.	M.
Length from occipital condyle to premaxillary border	.161
" " " " " postglenoid process	.030
" " " " " postfrontal process	.078
" " " " " preorbital border	.130
Diameters of orbit { vertical	.0250
Diameters of orbit { transverse	.0255

Measurements of Skull.	M.
Depth of malar bone at middle of orbit	.0195
" " zygomatic process at glenoid face (greatest)	.021
Width of top of muzzle at larmier	.0175
" at middle of supraorbital border	.051
" " malar bones	.077
" " zygomatic processes of squamosal	.0795
" of occipital condyles	.031
Elevation of occiput, including condyles	.054
Width of occiput at middle	.033
Depth skull at right angles to profile, at glenoid face	.046
" " " " " " orbit	.049
" " " " " " larmier, exclusive of teeth	.044
Depth of mandible at condyle	.071
" " " m. ii (middle)	.025
" " " P-m. iii	.022
Length of superior dental series	.0885
" to superior P-m. i	.0130
" " " m. i	.0470
" of " m. iii	.0180
" " " canine, crown	.009
" to inferior P-m. i	.012
" " " m. i	.0425
" of " dental series	.087
" " " m. iii	.022

The unique and beautiful specimen on which our knowledge of this species rests, was found in a formation of the Ticholeptus Miocene near Laramie Peak, Wyoming Territory, by my assistant, J. C. Isaac.

Merychyus arenarum, sp. nov. Sub-species **arenarum.**

This species was more abundant than the *M. leptorhynchus* during the Ticholeptus epoch, if we may judge from the number of specimens which have been procured. I enumerate here the five most important, viz.: No. 1, A skull which lacks the muzzle as far as the preorbital fossa, and the palate as far as the third premolar, and which has the mandible complete as far as the coronoid processes, and which is accompanied by fore and hind feet and other limb bones. No. 2, A muzzle and right side of the face including the orbit, with the entire dentition, including that of the premaxillary bone, and that of the right mandibular ramus as far as the second true molar inclusive. No. 3, A skull with a part of the mandible, of an immature individual, in which the last superior molar is just appearing, and the last two temporary molars are in place, and which is accompanied by a few bones of the limbs. No. 4, Palatal part of skull with nearly all the teeth, accompanied by perfect mandible with all the teeth, and a large part of the skeleton. No. 5, A skull from which the basi-

cranial region, zygomata, and left maxillary bone, have been lost. The measurements of No. 4 somewhat exceed those of the other specimens, so that it is doubtful whether it really belongs here.

The characters which distinguish this form from the *M. leptorhynchus* are not numerous. In the first place the front and muzzle are relatively wider. Secondly, the larmier is of a different form. Instead of being a horizontal slit, it is subtriangular, with the base above, and the angle below; thirdly the canine teeth are more robust in both jaws. But the position of the infraorbital foramen is slightly variable, and the width of the front in one specimen is about as in the sub-species *leptorhynchus*. The size of the canine is not invariable. I am therefore precluded from regarding the *M. leptorhynchus* as more than a sub-species.

As compared with the *M. elegans*, the strong convexity of the side of the face distinguishes it. The convexity continues from the malar region forwards above the infraorbital foramen, and nearly reaches the nareal opening. Judging from Leidy's fig. 11, Plate XI, of the Extinct Mammalian fauna of Dakota and Nebraska, the premaxillary bone of the *M. elegans* is flatter than in the *M. arenarum*. The infraorbital foramen has a more anterior position in the latter than in the former.

The size is always a little larger than in the type specimen of *M. leptorhynchus*.

Measurements.	M.
No. 1.	
Length from occipital condyle to postglenoid process	.037
" " " " " postfrontal process	.076
" " " " " preorbital border	.105
Transverse diameter of orbit	.030
Depth of malar bone at middle of orbit	.019
" " zygomatic process at glenoid face (greatest)	.019
Width at middle of supraorbital border	.062
" " malar bones	.096
" " zygomatic process of squamosal	.100
" of occipital condyles	.034
" " occiput at middle	.036
Elevation of occiput including condyles	.054
Depth of skull at right angles to profile at glenoid face	.041
" " " orbit (exclus. teeth)	.051
" of mandibular ramus at m. ii	.030
" " " " P-m. iii	.022
Length of last five superior molars	.064
" " true molars	.043
Diameters P-m. iii { anteroposterior	.010
Diameters P-m. iii { transverse	.010
Diameters m. i { anteroposterior	.013
Diameters m. i { transverse	.013

Measurements.	M.
No. 1.	
Diameters m. iii { anteroposterior.	.019
Diameters m. iii { transverse.	.015
Length of inferior dental series (axial)	.098
" " premolar series (axial).	.038
Long diameter of crown of canine	.007
" " " P-m. i.	.0086
" " " P-m. ii.	.0084
Diameters P-m. iv { anteroposterior.	.012
Diameters P-m. iv { transverse.	.009
Diameters m. ii { anteroposterior.	.0147
Diameters m. ii { transverse	.010
Diameters m. iii { anteroposterior.	.0223
Diameters m. iii { transverse.	.010

The specimens all came from the Ticholeptus beds near Laramie Peak, Wyoming, and were discovered by my assistant, J. C. Isaac.

Merychyus pariogonus, sp. nov.

The generic position of this species is uncertain, and it may belong to Merycochœrus or even to Eucrotaphus, as its otic bullæ are inflated. The doubt as to its position is due to the fact that the anterior part of the skull of the typical specimen is lost as far back as the anterior border of the orbit, and the second molar tooth. I place it here provisionally because the internal crescents of the superior molars are arranged as in *M. major* and *M. arenarum, i. e.*, with the anterior crescent excluding the posterior at the point of junction of the two.

The *Merychyus pariogonus* is about the size of the *Oreodon culbertsoni*. The braincase is full, so that the internal side of the temporal fossa is strongly convex, but without very prominent ridge along the pariëto-squamosal suture. The anterior temporal ridges unite at an acute angle, but the sagittal crest is obsolete as far as a point above the posttympanic process, where it gradually rises. The posterior temporal ridge is prominent superiorly, but is not produced beyond the line of the occipital condyles. It is discontinued in the direction of the supraauricular ridge, but continues downwards as an obtuse ridge on each side towards the foramen magnum. Between this and the squamoso-occipital angle is a large open fossa which is present in the species of this genus, of Merycochœrus and of Eucrotaphus, but is wanting in *Oreodon culbertsoni*. In the obsolescence of the posterior temporal crest it agrees with the last named species, and with some of those of Merycochœrus, but differs from *Eucrotaphus jacksoni* where it is low, and from *Merychyus leptorhynchus*, where it is well developed. In the size of the lateral occipital fossæ this species exceeds any of the others of this family. Below the depression, the posterior temporal crest rises abruptly, forming a convex edge which continues downwards nearly obsolete, on the suture between the post-

tympanic and paroccipital processes. It is not distinctly continuous over the auricular meatus. The paroccipital process is elongate and acuminate, and becomes compressed so as to be anteroposterior for the greater part of its length. The auricular meatus occupies but a small part of the space between the posttympanic and postglenoid processes. It is partially enclosed by the robust rounded ledge of the squamosal bone, which separates it from the postglenoid process. This ledge is much more developed than in any other species of this family known to me. The bulla of the petrous bone is longer anteroposteriorly than transversely, and its anterior and posterior borders coincide with the anterior border of the postglenoid process, and that of the paroccipital process. The postglenoid process is robust, much as in the large species of Merycochœrus, and not compressed as in *Merychyus leptorhynchus* and *M. arenarum*. The zygomatic arch is slender. The elevation of the posterior part of the zygomatic process of the squamosal has a different form from that seen in the species last named. It is angulate, not rounded. The position of the angle is different from that in *M. zygomaticus* in being more anterior, marking a point well in front of the anterior base of the postglenoid process. The border which connects the angle with the supra-auricular crest is then not vertical as in the species just mentioned, but is oblique, and it is also somewhat concave. The malar bone is shallow and stout, with truncate edge below. The squamosal process enters it to below the posterior third of the orbit. The postfrontal process is slender, and the postorbital process of the malar is elongate, meeting the former opposite the middle of the orbit. It is thus longer than in any species of the family known to me.

The frontal foramina are separated by an interspace equal to four-fifths the distance between each and the superciliary border. The pariëto-squamosal suture ascends posteriorly in a nearly straight line to within M. .015 of the posterior zygomatic crest. The posterior squamosal suture then turns directly downwards, reaching the depressed portion of the crest where it bounds the huge mastoid fossa and foramen.

The posterior part of the mandibular ramus, shows a regularly convex angular border commencing just below the condyle. The coronoid process is quite small and the short connecting edge between it and the condyle is not excavated below the level of the latter. The articular face of the condyle is directed upwards, and on the internal third, presents a face posteriorly also. The ramus diminishes rapidly in depth anteriorly. The masseteric fossa does not descend below the level of the second true molar, and is not sharply bordered anywhere. The internal pterygoid fossa on the other hand occupies the entire inner face of the angle between the condyle and the inferior border, and anteriorly to the line of the last inferior molar tooth.

The superior true molars have short crowns, as in Eucrotaphus and Oreodon. The anterior and median vertical ridges are very prominent, and the posterior vertical border of the posterior column projects to a slight

extent posteriorly. Enamel smooth. The last inferior molar is not so disproportionately larger than the second as in *M. leptorhynchus*, *arenarum* and *elegans;* and with the second, has little of a prismatic character. No cingula.

Measurements.	M.
Length from occipital condyle to postglenoid process...	.047
" " " " " postfrontal process...	.101
Vertical diameter of orbit	.086
Depth of malar bone at middle of orbit	.012
" " zygomatic process at posterior angle	.024
Width at middle of supraorbital border	.060
" " malar bones	.090
" of occipital condyles	.032
" " occiput at lateral crests	.036
" " " " condyles	.061
Elevation of occiput with condyles	.054
Depth of skull at glenoid surface	.058
" " " " orbit, exclus. malar	.054
" " mandible at condyle	.075
" " " " coronoid	.083
" " " " posterior edge of m. iii.	.042
Depth mandible at middle of m. ii	.028
Diameters superior m. ii { anteroposterior.	.016
Diameters superior m. ii { transverse	.016
Diameters superior m. iii { anteroposterior.	.020
Diameters superior m. iii { transverse.	.0155
Diameters inferior m. ii { anteroposterior	.015
Diameters inferior m. ii { transverse.	.012
Diameters inferior m. iii { anteroposterior.	.0225
Diameters inferior m. iii { transverse	.0115

A second specimen of this species consists of the occipital, pariëtal, and part of the frontal regions, with the right maxillary bone, and fragments of the left maxillary, of the mandible, etc. The latter demonstrates the position of the infraorbital foramen to be above the anterior border of the fourth superior premolar. The middle line of the occiput presents a keel on its superior half. The basioccipital bone between the paroccipital process is expanded laterally, and is without median angle or groove. Between the bullæ it is compressed, and its middle line forms a narrow truncation. Opposite the posterior third of the bulla, this surface ascends at an angle, and gradually widening, spreads into the general flattened convex inferior face of the sphenoid. The anterior part of the sagittal crest is a little better developed than in the typical specimen. The worn teeth indicate an old individual. The canine is large, and the first premolar has its roots well distinguished. The facial plate of the maxillary concave above second premolar. No appreciable diastema.

Measurements.	M.
Length of molar series	.081
" " premolars on bases	.041
Width of canine posteriorly	.010
Diameters P-m. iv { anteroposterior	.010
Diameters P-m. iv { transverse	.012

Of this species I have but two specimens, which were obtained from the Ticholeptus beds of Deep river, Montana, by my assistant, J. C. Isaac.

Merychyus elegans Leidy.

Proceedings Academy Philada., 1858, p. 24. Extinct Mammalia Dakota and Nebraska, 1869, p. 118, Pl. XI, figs. 1–11.

Niobrara river, Nebraska.

Merychyus zygomaticus Cope.

Ticholeptus zygomaticus Cope, American Naturalist, Feb. 1878. Bulletin U. S. Geolog. Survey Territories, 1878, p. 380.

This species is peculiar in having the posterior expansion of its zygomatic arch horizontal instead of vertical. It has a thickened external edge which continues into a strong posterior angle which projects behind the posterior margin of the postglenoid process. The auricular meatus is directed posteriorly in a way quite peculiar, resembling somewhat the position seen in some of the hogs. The malar bone is very prominent. The infraorbital foramen is above the contact of the third and fourth superior premolars. The larmier is large and its maxillary border descends posteriorly.

In size this species is between the *M. elegans* and the *M. medius*. If my identification of New Mexican specimens is correct, this species differs from the *M. medius* in the much less production of the premaxillary region, besides the smaller size.

Ticholeptus beds of Deep river, Montana ; J. C. Isaac.

Merychyus medius Leidy.

Proceedings Academy Philad'a, 1858, p. 25. Extinct Mammalia, Dakota and Nebraska, 1869, p. 119, Pl. XI, figs. 12–14. Cope U. S. Expl. Surv. W. of 100th Mer., G. M. Wheeler, iv, pt. ii, p. 324.

Niobrara river, Nebraska, Hayden ; Santa Fé, New Mexico, Cope.

Merychyus major Leidy.

Proceedings Academy Philada., 1858, p. 26. Extinct Mammalia, Dakota and Nebraska, 1869, p. 121, Pl. X, figs. 15–16.

This species, known hitherto from Leidy's descriptions of four of the superior molars, is the largest of the genus, and perhaps of the family. More information regarding it is much to be desired.

Headwaters of the Niobrara river ; from Loup Fork beds, according to Hayden.

LEPTAUCHENIA Leidy.

Extinct Mammalia of Dakota and Nebraska, 1869, 122. Proceedings Academy Philad'a, 1856, 88, (nomen nudum). loc. cit. 1656, 163 (nomen nudum).

As already remarked by Leidy, this genus is characterized by the presence of enormous vacuities of the superior surface of the muzzle. The genus might be described as lacking the usual superior osseous wall of the nasal cavities and maxillary sinuses. The generic diagnosis is as follows:

Otic bullæ inflated. Four premaxillary teeth. Nasal bones excessively contracted, leaving a wide interspace between them and the maxillaries. Symphysis mandibuli coössified.

This genus has but a short range in time, not having been yet found out of the Ticholeptus beds. It shows in its deficient ossification, and smaller size, that this line of the family was approaching its extinction, its decadence having already commenced in the genus Merychyus. The genera which follow in systematic order, Cyclopidius and Pithecestes, exhibit the last steps in the downward course.

I. Infraorbital foramen above P-m. iii.

"Three inferior incisors; nasal sinuses to middle of orbit; true molars .043; skull .135." (Leidy).....*L. major.*

"Nasal sinuses not extending so far posteriorly as in *L. major;* true molars .032; skull, .101." (Leidy).....*L. decora.*

"Nasal sinuses reaching to front of orbit; true molars .020; skull .085." (Leidy).....*L. nitida.*

Leptauchenia major Leidy.

Proceedings Academy Philad'a, 1856, p. 163; 1857, 89. Extinct Mammalia, Dakota and Nebraska, 1869, p. 124, Pl. XII, figs. 1–5.

Tributaries of White river, Nebraska.

Leptauchenia decora Leidy.

Proceedings Academy Philadelphia, 1858, p. 88; 1857, p. 89. Extinct Mammalia of Dakota and Nebraska, 1869, p. 127, Pl. XII, figs. 6–20.

Tributaries of White river, Nebraska.

Leptauchenia nitida Leidy.

Extinct Mammalia of Dakota and Nebraska, 1869, p. 129; Pl. XII, figs. 21–23.

White Earth creek, Dakota, tributary of the White river.

CYCLOPIDIUS Cope.

Proceedings American Philosophical Society, 1877, p. 221. *Brachymeryx* Cope, Ibidem, p. 220.

Dental formula: I. $\frac{6}{6}$; C. $\frac{1}{1}$; P-m. $\frac{4}{4}$; M. $\frac{3}{3}$. Premaxillary bones much reduced; mandibular rami coössified. Otic bulla inflated. Prelachrymal vacuities present, and confluent with enormous nasal vacuities, which are due to the excessive reduction of the nasal bones. Orbit closed behind.

This genus is Leptauchenia without superior incisor teeth, and with but two on each side below. I originally asserted the presence of superior incisor teeth, and it is true that there is in early life a minute tooth in each premaxillary bone, as indicated by the alveoli in a specimen which contains the full deciduous molar dentition. I have not seen the teeth themselves, and it is evident that they are early shed. In an adult specimen of *C. simus* it seems that the alveolar portion of the premaxillary bone has been absorbed.

The meatus auditorius externus occupies a more elevated position in this genus than in any other of the family. It is also directed somewhat posteriorly. There are postpariëtal foramina.

The cerebral hemispheres are not large, and scarcely rise above the plane of the summit of the large cerebellum. Convolutions three on each side, weakly defined.

The concavity of the superior border of the premaxillary bones, together with their upward production, leads me to suspect that the external nares were superior in position. This is the indication of an aquatic habit of life, such as is led by the hippopotamus. Like that animal, the nostrils in Cyclopidius were probably valvular to prevent the ingress of the water. The animals probably passed much of their time in the water, and the nostrils could be brought to the surface for the purpose of respiration, while the remainder of the head and body remained concealed. The prominent rim of the auditory meatus suggests a similar valvular closure of the organ of hearing, and is also a provision for its easy approximation to the surface of the water when necessary.

The milk dentition is like that of Artiodactyla in general. That is, in the superior series the third molar is more elongate and complex than its permanent successor, and the fourth is like the first permanent true molar in constitution. In the inferior series the anterior three teeth resemble the permanent premolars, while the fourth is trilobate.

In the loss of the incisor teeth and the subprismatic molars, we observe in Cyclopidius the same evidences of specialization already known in other types of Ungulates.

I know of but two species of Cyclopidius.

Cyclopidius simus Cope.

Proceedings American Philosophical Society, 1877, p. 221. *Brachymeryx feliceps* Cope, Ibidem, p. 220 (immature).

The specimens of this species in my possession embrace a complete skull with one zygoma and half of the brain-case wanting; a left maxillary bone with all the teeth; and three mandibular rami with dentition, all of adults. Of immature individuals, I have two muzzles with dentition of both sides, and six mandibular rami; in all, parts of thirteen individuals. The following description of the skull is taken from the specimen first named, which is the type of the species.

The cranium is wide and depressed, and the muzzle is short. The pro-

file descends at the orbits into the nasal vacuities, which cause a deep excavation of the facial plate of the maxillary region. The small nasal bones form a promontory below the level of the orbits, whose superior borders are convex. The maxillary bones rise at the end of the muzzle, forming, probably, with the confluent premaxillaries, a subquadrate projection. The superior side of this process is concave on its interior aspect forming a curved suture of an expanded nasal bone. Its anterior edge is also concave on their inner side, as though adapted to a forward-looking nareal opening. This anterior border is produced downwards into a free conical process which bounds the canine alveolus in front. This I suppose is all that there is of the alveolar portion of the premaxillary bone. The corresponding part of the other side is lost. There is a well-marked preorbital fossa. Its supero-interior border bounds the huge nasal vacuity on each side. The nasal bones form a narrow promontory, with convex superior face, which extends a little beyond a line connecting the middles of the preorbital fossæ. The vacuities excavate the frontal bones as far back as a line connecting the middles of the supraorbital borders. The frontal bone is thus of a Λ-shape. The anterior temporal ridges are well defined, but do not reach the free edge of the frontal bone. Their union into the sagittal crest is gradual. The brain-case is moderately elongate, the postorbital process of the malar bone marking the middle of the total length. In profile the posterior part of the skull is nearly straight. The sagittal crest is gently convex, and is not so deeply bifurcated posteriorly as in most other forms. The posterior temporal crests are expanded laterally, and continue well developed to above the meatus auditorius, into the superior edge of the zygoma. They are not continued downwards on the occiput, as in most of the other genera of the family, but resemble the species of Merychyus more than any others in this respect. The temporal fossa has a wide floor, due to the lateral extension of the meatus auditorius, and the glenoid portion of the squamosal. The superior edge of the zygomatic process of the squamosal is little elevated, and is regularly convex. The process is not produced as far anteriorly as the posterior border of the orbit. The malar bone is remarkable for its depth, exceeding in this respect any species of the family yet known. Its external face slopes obliquely outwards below, but not very much, and is slightly and uniformly convex. Its inferior edge is thickened and descends anteriorly, and then thins and rises continuously to the zygomatic process of the squamosal.

The occipital aspect of the skull is wide and low. Its superior region is slightly convex and roughened on each side of the median line. From and below this valley, the middle line presents a sharp carina, which disappears in a narrow convexity above the foramen magnum. Between this convexity and the meatus auditorius, the surface is concave. The occipital condyle is small, and the exterior half is more extensive than the posterior half. The paroccipital process is large. Its base diverges from the occipital condyle, and is adherent by its anterior face to the otic bulla,

without intervening ridge. The posttympanic mass is broken away. It is inferior in position to the auricular meatus. The latter, being directed posteriorly, is considerably produced behind the postglenoid process, leaving a wide postglenoid fossa. The postglenoid process is rather small, and its posterior face is entirely covered by the tympanic bone, while its interior edge is in close contact with the otic bulla. The bulla is of enormous size, and is a slightly compressed oval placed anteroposteriorly. It fills the entire space between the postglenoid process and the basicranial axis, and reaches anteriorly almost to the line of the anterior border of the glenoid region. The pterygoid process adheres to its internal wall for half its length, and it sends forwards on the external side of the pterygoid, a narrow acuminate apex. The internal extremity of the glenoid cavity is concave, and the surface descends, forming a robust peduncle, as large as the postglenoid process, to which the anterior part of the otic bulla is attached. This is a character I have not seen in any other species of the family. A wide surface, continuous with that of the glenoid face, extends on the external side of the pterygoid ala of the sphenoid, to the angle where it unites with the pyramidal process of the palatine. It there terminates abruptly, but the external angle marks the end of a ridge, which extends upwards and forwards to the postorbital process of the frontal. Anterior to this line the cranial wall is concave; posterior to it, convex. The processi pyramidales are divergent, and have thickened and rounded inferior edges. The maxillary bones are produced a little beyond their bases, leaving a notch between. The palatal surface is uniformly moderately concave.

The incisive foramina are large; the septa are wanting in my specimens, perhaps accidentally. The infraorbital foramen is above the middle of the fourth premolar tooth. The frontal foramina are further apart than in any other species of the family, being equidistant between the median line and the supraorbital border. There is an internal orbital foramen below the postorbital process, as in other species of the family. There are three postparietal foramina, two of which are on the squamosal suture. Below the anterior of these two is a large postsquamosal foramen. No supra or postglenoid foramina. The meatus auditorius externus looks equally externally and posteriorly. It is large and of oval outline, the long diameter being parallel to the superior border, which is the usual suprameatal crest. Its tympanic or anterior border is very prominent, while the posterior border is a little less so. A posttympanic tuberosity marks the middle of the inferior edge. Posterior to the meatus is the rather large mastoid foramen, which is above the internal base of the paroccipital process. The basicranial bones being lost, the characters of the basal foramina are not determinable. The posterior nares are deeper than wide. The palatonareal border is a Gothic arch, of which the apex is opposite the posterior border of the last molar tooth. I perceive no palatal foramina.

The median and posterior nasal sutures remain. The latter is a V with

the apex opposite to the frontal foramina. Lambdoidal suture confluent. The malosquamosal suture marks the posterior edge of the posterior orbital rim at the middle of the orbit. The pariĕto-squamosal suture has an inferior position in front. Opposite the front of the postglenoid process it converges inwards in line for the occipital bifurcation, and is continued as the pariĕtooöccipital suture, nearly to that point. The squamosal border, however, extends in a Z-form to the posterior temporal crest half-way between the bifurcation and the meatus auditorius. It embraces an area of the posterior face of the skull, and the posterior half of the rim of the auricular meatus.

The typical specimen presents only the alveoli of the canine and first premolar teeth; otherwise the dentition is perfect. The crowns of the second and third premolars are obliquely quadrate in horizontal section, both a little wider posteriorly than anteriorly. This is due to the presence of a half crescent of the internal side, whose posterior horn is attached to the external wall, while the anterior is free. The external faces of these premolars is slightly convex; of the fourth premolar is slightly concave. The first true molar is decidedly smaller than the second, and the second is smaller than the third. The external sides of the external columns are flat in the first true molar, but become more concave on the third. The anterior edges of the columns project; forming ridges; or in section, projecting angles. No intermediate ridges, nor cingula. The third superior true molar has a prismatic crown, no roots being visible in either of the adult specimens, of which the typical one is rather old, as indicated by the wear of the teeth. In the latter specimen the roots of the second true molar are apparent, although the crown is elevated. The first true molar is not prismatic, although the crown is not low. The specimen represented by the left maxillary bone contains the teeth which are wanting from the typical one. The section of the crown of the canine is a semicircle, the truncate face being posterior internal. It is not a large tooth, and is separated from the first premolar by a diastema equal to its diameter. The first premolar is one-rooted, the root with a groove on the internal side. The section of the base of the crown is a triangle, the faces being anterior, external, and posteroïnternal. Its inner face is concave above the base.

None of the separate mandibular rami are complete, all lacking the angle and condyle. The former is full and round, judging from a fragment in my possession. The ramus diminishes regularly in depth forwards. The symphyseal region is short, and its anterior face is very steep, except at the alveolar region, where it is everted forwards. No trace of suture. The internal pterygoid fossa is large and strongly marked, so that the inferior edge of the ramus is inverted, so that the surface is convex externally. The last molar is placed somewhat obliquely. The first and second premolars are directed outwards and forwards, and the incisors directed forwards.

There are two incisors on each side of the symphyseal line. They are very small and subcylindrical, and are closely packed between the canines.

The canines are much larger, with cylindric root and flat, incisor-like crown. The first premolar is still larger, and is of about the same form as the canine, from which it is only separated by a slight divergence of the crowns. There are no diastemata. The second premolar has a compressed triangular crown, with a median ridge on the internal side. Its long diameter is diagonal, running outwards posteriorly. The long axis of the third premolar is similar, while the other teeth are more nearly in line. In the third premolar the fossa interior to the median internal heel is much deeper than that posterior to it. The corresponding fossa is still larger in the fourth premolar, while the crown has a heel in the form of a transverse curved crest, separated from the median heel on the inner side by a fissure. The true molars increase rapidly in size posteriorly, but not so abruptly as in the *Pithecistes brevifacies*. The internal crescents are very flat, and the posterior edges of their columns project moderately. The external crescents are very convex. The prismatic character of the teeth increases much posteriorly, so that the roots of the third tooth are short, and the crown long. The enamel is minutely rugose.

The third superior temporary molar has two pairs of crescents. The anterior pair are, however, not so well developed as the posterior pair and the two valleys are soon obliterated by wear. The crescents are equal in the fourth temporary molar. The fourth permanent premolar is protruded at least as soon as the third true molar, sooner than the posterior column of the latter. In this it differs from the *Oreodon culbertsoni*, where the last true molar is protruded first, and is a cotemporary of both the third and fourth deciduous molars ;* and the *O. gracilis*, where the last true molar is a cotemporary of the third deciduous.

In the inferior temporary dentition, the lobes of the last molar are subequal, the posterior one being a little the larger. The protrusion of the last true molar is also probably delayed until the shedding of the deciduous series, as in the superior series ; but my specimens are either very young or fully adult, and therefore I cannot demonstrate this point as fully as in the case of the superior series.

Measurements of Skull.

	M.
Length from condyle to front of canine inclusive.....	.117
" " " " otic bulla (axial).....	.010
" " " " palatonareal notch,.....	.0575
" " " " anterior line of glenoid cavity.	.038
Depth of occiput, including condyle.....	.041
" at middle of orbit, exclusive of teeth.....	.037
" " infraorbital foramen " "	.016
" " premaxillary border " "	.028
Width at " " above.....	.022
" between orbits	.038

*Leidy. Ancient Fauna of Nebraska, 1853, p. 51, Pl. IV, figs. 1, 2.

Measurements of Skull.	M.
Width at malars below orbits	.086
" " zygomata at middle	.092
" " auricular meatus	.070
" of occipital condyles	.0275
" at middle of last molars inclusive	.049
" " " second premolars inclusive	.030
Diameters otic bulla { anteroposterior	.023
Diameters otic bulla { transverse	.018
Diameters otic bulla { vertical	.019
Diameters of nasal bones { length of fragment of	.024
Diameters of nasal bones { width at base	.0125
Length of dental series	.062
" " premolar series	.025
" " true molar	.038
Diameters P-m. iii { anteroposterior	.007
Diameters P-m. iii { transverse	.0065
Diameters m. i { anteroposterior	.0085
Diameters m. i { transverse	.0085
Diameters m. iii. { antereposterior	.0146
Diameters m. iii. { transverse (greatest)	.011
Depth of mandibular ramus at m. iii	.031
" " " " P-m. iv	.019
Length of symphysis	.0245
" " premolar series	.022
" " true molar	.035
" " of total dental series	.063
Diameters P-m. iv { anteroposterior	.0085
Diameters P-m. iv { transverse	.006
Diameters m. i { anteroposterior	.009
Diameters m. i { transverse	.0068
Diameters m. iii { anteroposterior	.016
Diameters m. iii { transverse	.0062

The second specimen with permanent dentition is of smaller size than the type, and the canine teeth are small. It may have been a female. The dental series, including the canine, measures M. 0.59; the premolar series, 0.23; the true molars, 0.31.

The number of specimens of this animal found in the restricted area of the Ticholeptus bed of Deep river, Montana, shows the former abundance of the species. It was probably gregarious, in the manner of the other Oreodontidæ. We can depict it as seeking the swamps of the shore for its vegetable food, and spending much of its time in the water when not feeding. It was doubtless a good swimmer, and the characters of its feet will be sought for with interest for light on this point. The use of the huge superior nasal vacuity of the skull of this genus and Leptauchenia can

only be guessed. Perhaps it supported an inflatable bladder like that of the crested seal, or a swollen muzzle like that of the saiga antelope.

Cyclopidius emydinus, sp. nov.

This species is represented in my collection by a nearly perfect cranium. It indicates an animal of about the same size as the *C. simus*. The differences between the two species may be enumerated in advance of the detailed description. Firstly, the external vertical ridges or crests of the true molars are directed obliquely forwards so as to overlap the external wall of the anterior crescent much more extensively than in *C. simus*. (2) The crowns of the true molars have a relatively greater transverse diameter. (3) There is a peculiar process at the external base of the otic bulla, between the paroccipital and postglenoid processes, which may be called the subtympanic process. (4) There is no median occipital keel. (5) The maxillary bone is prolonged posterior to the last superior molar, which it is not in *C. simus*. (6) The oblique orbitosphenoid ridge is wanting. (7) The otic bullæ are shorter and wider in their form. This character will require confirmation by examination of many individuals.

The skull is singularly depressed and expanded laterally, so as to present an outline not unlike that of some river turtles. The orbits are in the anterior half, and look forwards and upwards, as well as outwards. The muzzle is short, so that its lateral borders approximate rapidly to a narrow truncate extremity. The maxillary borders do not contract quite so abruptly, and are visible outside of the canthus rostralis, when the skull is viewed from above. The brain-case is depressed, and is expanded posteriorly, and narrowed at the anterior line of the zygomatic foramina. The posterior temporal ridges are much expanded, forming a wide rim round the brain-case posteriorly, which is continued into the squamosal processes of the zygoma on each side. The anterior temporal ridges approach each other very gradually on the middle line, and only reach the union into a sagittal crest a centimeter posterior to the frontoparietal suture. The edge of the crest is truncate, and it is not bifurcate posteriorly, as in most Oreodontidæ.

The occiput is broad and low, and differs in character from that of most other members of the family. Its posterior face is flat, only interrupted by a fossa on each side, just within the posterior edge of the meatus auditorius externus. This edge is continued downwards into the external border of a distinct mastoid process, which is also the external border of the occiput, deflected a little forwards. The paroccipital process is flat at the base, and is applied to the external half of the otic bulla. Its free extremity is subround. The mastoid process forms a prominent ala of its external side, having a transverse width equal to that of the base of the paroccipital. Its inferior edge is truncate obliquely outwards and downwards to a subacute angle. The occipital condyles are relatively small.

The external meatus of the ear looks outwards and backwards at an angle of 45° to the middle line. The prominent edge of the mastoid pro-

cess is directly below its anterior border. Thus the tympanic bone is directed obliquely downwards and forwards. Posteriorly it is separated by a groove from the mastoid process. Anteriorly it is separated by a fossa from an osseous mass which occupies the space between it and the postglenoid process. Before the skull was reconstructed from its fragments, this mass was observed to be entirely distinct from the postglenoid process, which it equals in height. Continuous with it, there descends another osseous body to near the line of the extremity of the mastoid process, with a truncate inferior edge, which is separated from the otic bulla by an open groove. The stylohyal ligament is probably inserted into a fossa at the anterior extremity of this groove. The postglenoid process is low and more extended transversely. The anteroposterior diameter is small. The glenoid surface is much extended transversely and terminates externally in a slight thickening. The zygomatic process of the squamosal bone is at first expanded horizontally and has a low convexity of the thin superior edge. Its vertically compressed portion is entirely supported by the malar, and does not extend so far forwards as the anterior edge of the zygomatic foramen. The malar bone is remarkable for the depth of its suborbital portion, which fully equals the diameter of the orbit. Its inferior edge presents a thickened angle downwards below the anterior part of the last superior molar. Its superoanterior angle terminates in a prominent rib of the side of the face, which extends along the inferior edge of the facial vacuity. Beneath the anterior part of the latter the face is concave. Above this concavity the ascending plate of the maxillary is convex in the vertical section, turning inwards at the apex to unite with the lateral part of the extremity of the nasal bone. The preorbital fossa is small and looks forwards and upwards.

The otic bullæ are larger than in any other Oreodontid. They are of a short oval form, somewhat truncate anteriorly and posteriorly. Thus they differ from those of *C. simus*, where they are elongate-oval. They only reach as far anteriorly as the middle of the internal extremity of the glenoid surface; while in *C. simus* they reach the line of the posterior outline of the zygomatic foramen. They terminate near the inferior internal point, in a little acute osseous apex, which is smaller than in *C. simus*. The bullæ approach so closely together that the bassioccipital is much narrowed, and the sides of its inferior surface are excavated so as to reduce the middle line to a narrow acute keel. The lateral excavations follow the posterior internal base of the bullæ, leaving a median table, which is itself excavated by a shallow fossa, which extends from the median keel to the foramen magnum. The median keel disappears anteriorly. The sphenoid is protuberant downwards as a narrow convex rib, which rises and disappears in the presphenoid. The descending sphenoid ala forms the posterior boundary of the posterior nareal trough, and makes a strong angle with the pyramidal process of the palatine, which is turned outwards. The pterygoid squama terminates in an apex which points downwards and posteriorly towards the apex of the otic bulla. The palatonareal border is

V-shaped, and is in line with the posterior edge of the maxillary bone. The latter projects beyond the last molar tooth as far as the anteroposterior diameter of the latter. It has no projection in the *C. simus*. There is no notch between the maxillary bone and the processes pyramidalis of the palatine. The palate is of nearly equal width from the last molar to the third premolar; its roof is gently concave posteriorly; nearly flat anteriorly.

The premaxillary bone is a narrow strip which rises nearly vertically from its short alveolar border, and is curved outwards above in agreement with the expansion of the anterior edge of the maxillary, to which it is united by simple suture. The nasal bones are of remarkable form. Together they enter the anterior part of the frontals in a V-shape, and extend forwards in a narrow shaft. Opposite the anterior borders of the orbits the shaft begins to widen gradually, and the surface to flatten, until they reach the posterior angle of the ascending part of the maxillary. Each one then expands outwards, terminating in a semi-disc which fits the concavity of the superior edge of the maxillary above mentioned. The entire shape of the nasal bones is that of a spade with a triangular apex to the handle, and the short blade at the opposite (anterior) extremity. The frontal bone is V-shaped, the angle posteriorly directed, and engaged between the parietal bones, and each branch terminating above each orbit. Narrow prolongations extend anterior and posterior to the orbit, joining the lachrymal and malar bones respectively. Its median suture is, like that of the nasal bones, well defined. The alisphenoid and parietal have extensive connection. The parietosquamosal suture is horizontal in front; it then gradually rises. It is not associated with a ridge as in some other species. The occipital forms the posterior five millimeters of the sagittal crest.

The nasal opening is subtriangular, with the base above, and is directed anteriorly. The facial vacuities are enormous, and excavate the frontals to a point which make the anterior third of the orbit's diameter. They are only separated on the median line by the very narrow isthmus of the nasal bones. The infraorbital foramen is above the anterior part of the fourth superior true molar. The frontal foramina are small, and are not symmetrical. That of the left side is half-way between the median suture and the superciliary border; the other is nearer the superciliary border. No supraglenoid foramen. Postsquamosal present; that part of the cranial walls is injured. The anteroposterior diameter of the orbit exceeds the vertical. The auricular meatus is the largest known in the family, and it has a prominent border and regularly oval outline. Its long diameter rises posteriorly from the horizontal. It is more laterally and less posteriorly directed than on the typical and only skull of *C. simus*. The foramen magnum has an openly angulate superior border. Jugular, condyloid, and carotid foramina not obvious, owing to the close contact of the otic bulla with surrounding bones. *Foramen ovale* larger than the *F. lacerum anterius*, and external to it in position. *F. rotundum* still larger, inferior in position, bounded on the external side by a

tuberous projection of the angle from the anterior edge of the glenoid surface. There is a deep fossa at the internal base of the postglenoid process, which possibly enters a foramen. No postglenoid foramen.

Although the skull of the *Cyclopidius emydinus* is more robust than that of *C. simus;* the length of the tooth-line is the same. The incisive edge of the premaxillary bone displays one empty alveolus, from which the single incisor was easily shed. The canine is not large, and the base of the crown has a regularly convex anteroexternal face; apex lost. The diastema posterior to it is equal to its diameter. The crowns of the premolars are worn; they are of about the size and proportions of the *C. simus*. The true molars differ, as I have already pointed out, in their greater transverse diameter, and the greater anterior prolongation of the anterior horns of the posterior external crescents. The deep notch which is enclosed between this fold and the wall of the crescent in front of it is filled with cementum. As to the form of the true molars, the transverse diameter of the first considerably exceeds its anteroposterior diameter; in the *C. simus* the former diameter is equal to the latter. In *C. emydinus* the last true molar is as wide as its length without the heel; in the *C. simus*, the transverse diameter is much less. In *C. simus* the heel is more prominent, and is recurved into a vertical ridge, which is wanting in the *C. emydinus*. In *C. emydinus* this tooth shows but little of the prismatic character, as the roots are of usual length.

The lower jaw of this species is not yet known.

Measurements.

	M.
Length of skull along base	.129
Length from condyles to posterior edge of zygomatic foramen	.042
Length from condyles to palatonareal foramen	.063
" " " " line of last true molar	.071
" " occipital crests to line of orbits	.074
" " " " " facial vacuities	.084
" " " " " ascending process of maxillary bones	.115
Length from occipital crest to free end of nasal bones	.126
Elevation occiput, including condyles	.045
" of front at middle of orbit, without molars	.035
" " maxillary bone at P-m. iii	.015
" " " " " P-m. i	.025
Width of skull at occipital condyles	.0675
" " " " superior edge of meatus auditorius	.057
" " " " middle of zygomatic foramina	.092
" " brain-case at middle of zygomatic foramina	.029
" " skull at orbits	.083
" " " between orbits	.047
" " muzzle at superior edge of nares	.0215

Measurements.	M.
Diameter external nares { vertical	.014
Diameter external nares { transverse above	.017
Diameter of a facial vacuity { anteroposterior	.030
Diameter of a facial vacuity { tranverse	.013
Diameter of orbit { anteroposterior	.023
Diameter of orbit { vertical	.019
Diameter of zygomatic foramen { anteroposterior	.053
Diameter of zygomatic foramen { transverse	.026
Diameter of foramen magnum { vertical	.0095
Diameter of foramen magnum { transverse	.013
Diameter of meatus auditorius { vertical	.009
Diameter of meatus auditorius { anteroposterior	.011
Diameter of otic bulla { vertical	.025
Diameter of otic bulla { anteroposterior	.025
Diameter of otic bulla { transverse	.022
Width between canine teeth	.008
" " last true molars	.0285
Length of dental series	.065
" true molar series	.0343
" premolar	.0254
Diameters P-m. ii { anteroposterior	.0056
Diameters P-m. ii { transverse	.0050
Diameters P-m. iv { anteroposterior	.0070
Diameters P-m. iv { transverse	.0080
Diameters m. i { anteroposterior	.0075
Diameters m. i { transverse	.0110
Diameters m. iii { anteroposterior	.017
Diameters m. iii { transverse (with external rib)	.012

The only specimen of this remarkable species known to me was found in the valley of Deep river, Montana, by my assistant, Mr. J. C. Isaac. The wear of the true molars shows that the animal was of full age, though not old.

PITHECISTES Cope.

Proceedings American Philosophical Society, 1877, p. 219.

This genus represents the final term in the decadence of the once powerful and numerous family of the Oreodontidæ. It is unfortunately established on a mandibular ramus only, and although some maxillary bones are referred to it with much probability, they are not preserved in such a way as to demonstrate the presence of the large nasal sinuses characteristic of Leptauchenia. I, however, suspect that they occur. The genus further resembles Leptauchenia in the coösification of the mandibular rami, and the reduction in number of the incisor teeth. In *P. brevifacies* there is but one inferior incisor tooth on each side. As reduction in the superior incisors usually precedes reduction in

those of the lower jaw, I suspect that the former were absolutely wanting in this genus. If so, we have in the Orcodont line the same process of reduction above, as has taken place in other lines of Artiodactyla at the latest or modern stage of their history.

In Pithecistes the inferior canine is caniniform, and masticated in contact with the superior canine, owing to the great abbreviation of the symphyseal region.

The diagnosis of the genus is as follows:

Inferior premolars three; incisors one. Canine caniniform, masticating with the superior canine. No diastema. Symphysis coössified.

Two species are referred to this genus without conclusive evidence as to the number of their premolars. It is probable that they have but three, since their superior fourth premolars are of reduced size and incomplete type of form.

Pithecistes brevifacies Cope.

Proceedings American Philosophical Society, 1877, p. 219.

Ticholeptus beds of Deep river, Montana. Discovered by J. C. Isaac.

Pithecistes decedens Cope, sp. nov.

Established on a right maxillary bone, which contains the fourth premolar, the first and second true molars, and part of the alveolus of the third true molar. The last named tooth was not probably entirely protruded. This, with the moderate wear of the fourth premolar, indicates that the animal was fully grown, though young.

The species differs from all the members of the family whose dentition is known to me in the small size and simplicity of structure of the fourth premolar. The internal crescent of this tooth bounds only the posterior three-fourths of the external wall, and therefore leaves the anterior edge of the latter free. It is, moreover, not very convex, and its edge is not so elevated as is that of the external wall. The latter is flat on the external side, and its anterior marginal angle corresponds with the point of junction of the anterior extremity of the internal crescent. The true molars have the anterior horns of their crescents prominent, being sections of well-developed vertical columns. In this they differ from those of the *P. heterodon*, where these ridges are very weak.

The malar process of the maxillary bone is robust and prominent, and begins to expand opposite the first true molar. It presents a tuberosity downwards. The infraorbital foramen issues above the front part of the fourth premolar.

Measurements.		M.
Diameters P m. iv	anteroposterior	.006
	transverse	.005
Diameter m. i	anteroposterior	.0087
	transverse	.0077
Diameters m. ii	anteroposterior	.0115
	transverse	.006

Ticholeptus beds, Deep river, Montana. J. C. Isaac.

Pithecistes heterodon Cope.

Cyclopidius heterodon Cope, Proceeds. American Philos. Society, 1877, p. 22.

In this species the fourth premolar has the same form as in *P. decedens*, but the first true molar differs much in the more prismatic shape, and the absence of the external vertical ribs. It is quite possible that it does not belong to this genus.

Ticholeptus beds of Deep river, Montana. J. C. Isaac.

AGRIOCHŒRUS Leidy.

Proceedings Academy, Philadelphia, 1850, p. 121. Extinct Mammals Dakota and Nebraska, 1869, p. 131 (as family *Agriochœridæ*).

Orbit not closed behind. Fourth superior premolar with two external Vs. Fourth inferior premolar like true molars. Otic bulla inflated. Premaxillary bones distinct; no vacuities in the facial bones.

This genus commences cotemporaneously with the genus Oreodon, and persists longer, viz.: to the close of the John Day epoch. It represents a distinct line of succession from that which we have been considering, and one which contains but two known terms. Next to Agriochœrus comes, in this line, the genus Coloreodon Cope, which outlasted its predecessor so far as is yet known. It commenced with it in the John Day epoch, and continuing into the North Fork beds, which are of later age, did not appear later. This series Leidy regarded as a family distinct from the Oreodontidæ. For the present I prefer the view of Gill, that it constitutes a subfamily, the Agriochœrinæ.

This genus presents us with one of the very few cases in the suborder Artiodactyla, in which the last premolar approaches (above) or accomplishes (below) identity of structure with the true molars. This degree of complication was attained at the same period by both the equine and rhinocerontic lines of Perissodactyla, and all existing members of that order exhibit it. In the Agriochœridæ it made a beginning, but soon disappeared from the earth, and no Artiodactyle has developed such permanent premolars successfully since.

In the characters of the skull this genus is less robust than the Oreodontidæ; but the general skeleton remains unknown.

Five species have been described which are referable to this genus, and two others are now added. One of the former is without premaxillary or superior incisor teeth, and I therefore regarded it as representing a distinct genus under the name of *Merycopater*. It, however, appears that no specimens exist in our museums which exhibit this part of the skull in other species of the genus, so it is absolutely uncertain whether Agriochœrus possesses those teeth or not. The species may then be distinguished as follows:

I. Otic bullæ compressed, base anteroposteriorly ovoid.

a. Foramen infraorbitale above junction of P-m. iii and iv.

Front narrower; internal wall of fourth premolar not complete.....*A. antiquus.*
Front wider; skull shorter and higher; internal wall of inferior P-m. iv complete.....*A. latifrons.*
aa. Foramen infraorbitale above junction of P-m. ii and iii.
Front medially concave, laterally descending to orbits; sagittal crest short.....*A. trifrons.*
II. Otic bullæ mammiform with triangular base.
Front convex; nasal bones acute posteriorly; fourth inferior premolar complete; infraorbital foramen above junction of P-m. iii and iv.....*A. guyotianus.*
III. Otic bullæ oblong, constricted at the middle.
Infraorbital foramen above junction of P-ms. ii and iii; front plane; nasal bones truncate posteriorly; postglenoid process robust.....*A. ryderanus.*

Besides the above, Leidy has described an *A. major** as near to the *A. antiquus*, but of larger size. Marsh has described a small species from the Uinta formation under the name of *A. pumilus.*† Lydekker figures and describes a superior molar tooth from India as probably belonging to this genus.‡ It is stated by him to have been found in the earlier pliocene formation. If this determination be correct, it represents the latest known species, as the *A. pumilus* of Marsh is the earliest. Owing to incompleteness in the descriptions of these species I cannot include them in the above synoptic table.

Agriochœrus antiquus Leidy.

Proceedings Academy Philadelphia, 1850, 121; 1853, 392; 1854, 157; 1857, 89. Ancient fauna of Nebraska, 1853, p. 24, Pl. I, figs. 5–10. Bronn Lethæa Geognostica, 1856, 933; Leidy Extinct Mammalia Dakota and Nebraska, 1869, 132, Pl. XIII, fig. 4.

White River epoch of Nebraska and Dakota.

Agriochœrus major Leidy.

Proceedings Academy Philadelphia, 1856, p. 164; 1857, 89. ? *Eucrotaphus auritus* Leidy, Owen's Report Geological Survey, 1852, p. 563, Pl. XV, figs. 1–3. Ancient Fauna of Nebraska, 1853, p. 56; Pl. VII, figs. 1–3. Bronn Lethæa Geognostica, 1856, 931.

White River formation of Dakota and Nebraska.

Agriochœrus latifrons Leidy.

Proceedings Academy Philadelphia, 1867, p. 32. Extinct Mamm. Dakota, Nebraska, 1869, p. 135, Pl. XIII, figs. 1–3.

White River epoch of Dakota and Nebraska.

* Extinct Mammalia of Dakota and Nebraska, p. 134.
† Amer. Journal Science and Arts, 1875, p. 250.
‡ Paleontologica Indica.

Agriochœrus trifrons sp. nov.

This species is known to me by a single cranium of an immature individual. It lacks of perfection only the basioccipital, the pterygoid, and the alveolar border of the premaxillary bones. It retains the third and fourth deciduous premolars, while the third true molar is still in its alveolus, where it is exposed in place.

Although the specimen is immature, its characters will not permit me to place it with any other species known to me. I have specimens of like age of the *A. guyotianus*, and these are quite different. From *A. ryderanus* it differs in the form of its otic bulla, etc.

The muzzle and front form a flat horizontal profile, while the pariëtal region is convex. The profile descends gently to the supraoccipital border, or inion. The muzzle is compressed above and below the canine alveolus, and there is a concavity above the third and fourth premolars, and behind the foramen infraorbitale above this fossa the lachrymal region is convex. The nasal bones are lost, so that the form of their posterior suture cannot be ascertained. The frontal bones are gently concave in transverse section between two lines produced forwards from the anterior extremities of the temporal ridges, that is at the postorbital constriction of the cranium. These lines are represented by a rounded longitudinal angle, from which the frontal bone descends to the superciliary border on each side. A trace of this form is seen the *A. ryderanus*. The supraorbital borders diverge outwards and backwards to the postorbital processes. These are prominent horizontally, and are abruptly decurved at the apex. The temporal ridges enclose an urceolate area, having a gentle convexity in their direction before they unite at a point more posterior than in the other species, that is above a line connecting the anterior borders of the postglenoid processes.

The malar bone is slightly concave on the external face, and is moderately deep, and not thick. The squamosal part of the zygoma is rather slender, and does not rise above the postglenoid process. Its superior edge continues without interruption into the posterior temporal crests, and so into the supraoccipital. The postglenoid process is like that of *A. guyotianus*, narrow and produced downwards. Paroccipital lost. The otic bulla is large, its anterior edge extending anterior to the postglenoid process. It is nearly twice as large as in *M. guyotianus*, and extends much further forwards. It presents two flat sides, one external, the other outwards and forwards, and a convex side inwards and backwards. These sides meet at an angular edge below, which runs outwards and backwards. The sphenoid bone is convex between the bullæ. Basioccipital lost. The palatonareal border is convex, and is opposite the middle of the second true molar. In the mature skull it would be probably more posterior. The palate is everywhere concave in transverse section.

The frontopariëtal suture is broadly convex, and is opposite the anterior edge of the glenoid surface, and 25 mm. in advance of the sagittal crest. The anterior processes of the bone on each side of the nasals are wide and truncate, and do not extend beyond the interior suture of the lachrymal

bone. The latter is about as long on its superior sutures as it is deep at the orbit. It presents a distinct preorbital angle above a prominent tubercle. The occipito-parietal suture extends well forwards, 30 mm. in advance of the crest. The squamosal does not reach to the lateral occipital crest.

The infraorbital foramen occupies the position it has in the *A. ryderanus*. In a young specimen of *A. guyotianus* it has the same position as in the adult. The frontal foramina are about as far apart as each is from the supraorbital border. There is a postparietal foramen on the pariëto squamosal suture, and there are three postsquamosals, two of them near together, and near the posterior suture, the other below the postparietal foramen. *Foramen ovale* oval, about as large as the *F. rotundum*, and separated from the foramen lacerum by the produced base of the inferior ala of the sphenoid bone. Palatine foramen opposite the third deciduous premolar.

Superior canine teeth robust, bases of crown one-half lenticular, the posterior face truncate. A considerable diastema anterior to first premolar, and a short one behind it. Other teeth in continuous series. First and second premolars two-rooted; absolutely simple. Third and fourth crown of first of usual form. First true molar smaller than second. Enamel minutely roughened.

Measurements.	M.
Length from supraoccipital crest to canine inclusive	.180
" " " " " front of bulla	.036
" " " " " penultimate molar	.108
" " " " " orbit (axial)	.105
" " " " " front of orbit	.126
" of sagittal crest	.046
" " superior molars (last included)	.076
" " premolars	.036
Diameters M. i { anteroposterior	.063
Diameters M. i { transverse	.014
Diameters M. ii { anteroposterior	.0165
Diameters M. ii { transverse	.020
Width of skull at postglenoid inclusive	.077
" " " middle of zygomas	.050
" " " fundus of canine alveolus	.038
" between canines	.020
" " second true molars	.033
" of skull at postfrontal processes	.076
" " " between anterior rims of orbits	.066

The label from this specimen is lost. It is, however, from Oregon, and to judge from the color, from the true John Day epoch, rather than the North Fork bed.

Agriochœrus guyotianus Cope.

Hyopotamus guyotianus Cope, Proceedings American Philosophical Society, 1878, p. 77. *Merycopater guyotianus* Cope, American Naturalist, 1879, p. 197, Proceeds. Amer. Philos. Soc., 1879, 375.

Three crania, one with nearly entire mandible, and numerous fragments with mandibles, represent this species in my collection. It is the most abundant species of this genus in the John Day beds of Oregon.

The cranium is of peculiar form. It is elongate from the orbits backwards. The muzzle is elevated and compressed, so that the profile is horizontal, with subordinate irregularities. The occiput is therefore low as compared with the muzzle. The zygomata are rather slender, and are not expanded. The side of the muzzle is concave just below the superior border of the maxillary bone and above the fundus of the canine alveolus. The inferior part of the maxillary is concave from below the anterior border of the orbit to the line of the canine alveolus. The region above and anterior to the lachrymal bone is convex, leaving the flat nasal bones a little depressed. The frontal has a convex swelling on the middle line just posterior to the frontal foramina, from which point the surface slopes gradually and evenly to the supraorbital borders, and not in two planes, as in *A. trifrons*. At the front of the orbit the section of the frontal bone is convex at the sides and a little so at the middle. The supraorbital border is short and concave; not long and straight as in *A. trifrons*, and the postfrontal process is moderately prominent, and is not decurved. The anterior temporal ridges do not reach them. The former converge in nearly straight lines at an acute angle to a long sagittal crest. This in turn bifurcates into two very prominent posterior temporal crests, which overhang the occipital condyles. The brain-case is an elongate-oval, and the olfactory portion is long and narrow, but not especially constricted at any one point. There is a prominent small tuberosity at the inferior part of the lachrymal bone; above it the preorbital border is not defined as far as the beginning of the supraorbital. The postfrontal process originates below the anterior temporal surface which is continued along its posterior edge. The malar bone is concave on its external face. The zygoma is compressed, and has a long low superior convexity behind. Its crest continues into a fine, low, posttemporal crest, which turns posteriorly above to its prominent posterior expansion above mentioned. The latter turn outwards at the apices, and send a low ridge downwards towards the occipital condyle. Below, the latter form a low angle on each side, which separates a median from a lateral plane. Above, the occiput is deeply concave, and has a trace only of median keel.

The basicranial axis is flat and rather wide between the otic bullæ. The occipital condyles have distinct inferior boundaries which are separated by a flat interval. The posttympanic region is wide, and is bounded inferiorly by the deep styloid fossa. This is surrounded internally and posteriorly by the funnel-shaped base of the paroccipital process, which extends first posteriorly as a longitudinal lamina, and then outwardly. Its

edge terminates in a rough band which curves upwards and backwards to a point above the line of the occipital condyle. It is separated by a shallow groove from the corresponding posttympanic ridge. The tympanic bone is not so long as in the species of Oreodontinæ, and presents a tuberosity externally. Like the paroccipital its base unites with the otic bulla. The bulla is small. Its base is extended towards the postglenoid process, but it is well separated from it, and does not reach the line of its anterior border. It presents a face anteriorly, and one inwards. The postglenoid process is narrow transversely, the depth and width being equal, and is elongate downwards.

The coronoid process of the mandible is short, but has a base extended anteroposteriorly. The articular face of the condyle is convex anteroposteriorly, and is extended downwards on the inner side behind. The horizontal ramus is slender, and has a straight inferior border. (The angle is broken away from this specimen.) The symphysis is oblique and nearly straight in profile. It is moderately elongate, and has the suture persistent. There is a tuberosity looking downwards from its posterior extremity, where it is rounded-compressed.

The facial part of the lachrymal bone is longer than deep, and the lateral anterior part of the frontal is wide and obtuse, and extends anterior to the lachrymal. The nasals extend posteriorly to terminate in an acute angle which is above the anterior edge of the orbit. The frontoparietal suture extends across the space between the anterior temporal ridges at a point half way between the anterior border of the orbit and the anterior glenoid margin. The malomaxillary suture has no anteroinferior process. The mastoid forms a distinct mass between the exoccipital and squamosal. The sutures are largely coössified.

The infraorbital foramen is above the contact of the third and fourth premolars. The space between the frontal foramina is about one-sixth the interorbital width. There is a large postparietal foramen on the parietosquamosal suture, and there are two small postsquamosal foramina, in line above the posttympanic tuberosity. The mastoid foramen is small, and is not situated in a fossa of any extent, as is the case with the species of the Oreodontinæ. There is a large foramen intermediate in position between that of the anterior condyloid and the jugular. Anterior and a little external to it and slightly elevated between the confluent base of the paroccipital process and the otic bulla is another foramen, perhaps the jugular. Between the posterior base of the bulla and the basisphenoid, is a smaller foramen, probably the carotid. The other foramina are yet concealed by the matrix.

The teeth do not differ in their form from those of other species of the genus. The second and third premolars have triangular bases, the second the narrower. The first has two roots. It is accidentally lost from one side, which circumstance led me to suppose at one time that this species has but three premolars above. The fourth premolar has its posterior external V well developed, though a little smaller than the anterior. In the

specimen now described, the posterior internal rudimental cusp is quite well developed; in the two other specimens now before me it is not so large. The superior canine is elongate, and not very robust, and its convex anterior border is directed partly posteriorly at the apex. The enameled portion of the crown is quite short. The premaxillary bones are narrow and weak, and are separated so as not to be in contact on the middle line. Its border displays two minute alveoli, from which teeth have been shed. I do not suppose that their presence is constant in the species. The external alveolus is twice the diameter of the internal. The inferior incisors are of normal number, but are very narrow, and much crowded. The canines are very narrow, but are longer than the incisors. The first inferior premolar is more caniniform than in any other species of Oreodontidæ known to me. The crown is a compressed oval in section, and is not expanded at its base. It is enameled to within 5 mm. of the alveolar border. A considerable diastema separates it from the second premolar. The description of the remaining teeth I take from a separate ramus of similar dimensions, as they are concealed in the type by their position in juxtaposition with the cranium. The cusps of the true molars are pyramidal and acute, and entirely separate from each other. The external faces of the external are convex, their internal faces flat. The external faces of the internal are convex, the internal faces concave at the base, and convex near the apex. The anterointernal angle of the posteroexternal cusp extends to the base of the anterointernal cusp. The only difference between the first true molar and the fourth premolar, is that the anterior crest of the anteroexternal cusp is continued round to the front of the anterointernal cusp, and to the internal side of the crown; and the apices of the two anterior crests are separated by a shallow notch. The second inferior premolar has two roots. The heel of the third true molar is well developed, and is convex posteriorly.

Measurements.	M.
Length from occipital condyles to postglenoid process	.038
" " " " " preglenoid border	.058
" " " " " postfrontal process.	.104
" " " " " canine, inclusive	.226
" " orbit to canine inclusive	.085
" of mandibular ramus from condyle	.176
" "symphysis mandibuli below	.049
Width of occipital condyles inclusive	.046
" " occiput above	.045
" "between otic bullæ	.016
" "at postglenoid processes inclusive	.079
" "of skull above glenoid surfaces	.100
" " " below orbits	.099
" " " between orbits	.068
" " " at fundus of canine alveoli	.040

Measurements.	M.
Width of skull between last upper molars, inclusive...	.070
Depth of occiput to foramen magnum.....	.043
" " " " basioccipital bone.....	.058
" " skull at last superior molar, exclusive.....	.058
" " " " first premolar, exclusive	.055
" " ramus mandibuli at front of M. iii.....	.035
" " " " " " " P-m. iv.....	.027
" " zygomatic arch above glenoid facet.....	.027
Diameters of base of crown of superior canine { anteroposterior.....	.009
{ transverse.	.0085
Length of superior diastema.....	.022
" " premolar series.....	.039
" " true molar series.....	.043
Width of premaxillary bones together.....	.043
Diameters of base crown inferior P-m. i; anteroposterior.....	.0085
Length inferior diastema.....	.015
" " last three premolars.....	.031
" " true molars.....	.046
" " last true molar.....	.021
" " third premolar.....	.009
" " fourth.....	.012
Horizontal diameters of otic bulla { anteroposterior. ..	.019
{ transverse.....	.017

The specimens of this species which I have seen, are from the John Day river, and were obtained by Messrs. Sternberg, Wortman and Davis. The skull from which the above description was taken is the most perfect one of the genus Agriochœrus which has yet been found.

Agriochœrus ryderanus Cope.

Coloreodon ryderanus Cope, Bulletin U. S. Geological Survey Territories, vi, p. 173.

This species is represented in my collection by three nearly complete skulls without mandibular rami. While of the general size of the *A. guyotianus*, this species displays various well marked peculiarities. The most important of these are (1) the shape of the otic bulla, in which it differs from all other known Oreodontidæ; (2), the position of the infraorbital foramen, in which it resembles in this genus only the *A. trifrons*; (3), in the form of the nasal bones posteriorly, in which it differs from the species where this part is known; (4), in the form of the palatonareal border; (5), in the form of the postglenoid process; (6), in the outline of the section of the frontal bone.

Agriochœrus ryderanus has the muzzle compressed laterally and flattened on top, as seen in the *A. guyotianus* and *A. trifrons*, and the side of the

muzzle has three distinct fossæ. The largest of these is above the position of the fundus of the superior canine alveolus; the second is below the fundus; and the third is behind the position of the infraorbital foramen, and above the third and fourth premolars, and the first true molar. The lachrymal region is plane, and the nasals are flat. The frontal bone is nearly flat in section between the posterior borders of the orbits, but each is decurved to the lachrymal opposite the anterior border of the orbit. There is no indication of the three planes of the infraorbital region characteristic of the *A. trifrons*, nor of the median convexity of the *A. guyotianus*. The anterior temporal ridges commence about the middle of the width of each frontal bone, and unite after a shorter independent course than they have in *A. guyotianus* into a long, narrow saggital crest. This bifurcates posteriorly into two prominent lateral crests, which are directed downwards and soon terminate, but which send forwards and downwards a delicate posttemporal crest. This passes without interruption into the superior edge of the zygomatic arch. This arch is not expanded either upwards or laterally, and is rather weak. The external face of the malar bone is gently concave, and the inferior edge is rather wide, is truncate, and grooved along the middle. The occiput is deeply concave between the crests, and below them is gently convex. The superior edge of the foramen is deeply notched at the middle, much as in *M. guyotianus*.

The occipital condyles are large, and their inferoanterior angles are produced horizontally for a short distance, forming short processes which are separated by a concavity of the basioccipital bone. The latter is plane below, but anteriorly develops a low meridian angle, which, widening on the sphenoid, causes its inferior face to be convex. The posttympanic element is distinguishable from the mastoid by a superficial groove, and a slightly free apex, and the mastoid from the paroccipital by a slight groove. The external base of the paroccipital extends but 5 mm. external to the line of the external border of the occipital condyles, and is therefore much less prominent than in the majority of species of Oreodontinæ. The base of the paroccipital has a posterior and an anterior face, nearly at right angles with each other. The latter is continued into the pinched posterior prominence of the auditory bulla, and encloses on its external side, with the apex of the posttympanic, the deep stylohyoid fossa. The tympanic bone is represented by a tuberosity below the meatus, and a laminar expansion on the posterior face of the postglenoid process. The otic bulla's long axis is inwards, and a little posterior from the internal side of the postglenoid process, from which it is separated by a narrow interval. The bulla is constricted at right angles to its long axis, in two parts. The external part is subglobular with the side next the postglenoid process flattened. The internal part is roughened, displays a flat side posterointernally, and has an apical keel which extends posteriorly and a little externally into the base of the paroccipital processes. This form is not known in any other species of the family. The postglenoid process is more robust than in either *M. guyotianus* or *M. trifrons*. Its width and thickness are equal,

and are a good deal longer than its height; in the species named the height equals the other measurements. The pterygoid ala rises opposite the middle of the end of the glenoid surface, and the angle of its junction with the pyramidal process of the palatine is considerably in front of the middle of the trough of the posterior nares. Its edge posterior to this angle is shallowly grooved. The palatonareal border differs from that of any other species of the family known to me. It is acute in front, forming a Gothic arch, its apex being opposite the middle of the superior third true molar. In a young *M. guyotianus*, the only specimen of that species in which it is perfectly preserved, it is rounded, and extends to the posterior part of the second true molar. In an adult specimen, where the middle portion of the margin is lost, it extended at least as far forwards; but its form is uncertain. The palate in the *A. ryderanus* is strongly concave throughout.

The lachrymal bone has a different form from that of a *A. guyotianus*, more resembling that of *A. latidens* figured by Leidy. Its anterior superior angle is not produced, and its outline is a little deeper than long. The anterior lateral prolongation of the frontal extends beyond it by nearly its width, and is wide, and terminates in an obtuse angle. The posterior edge of the nasals is broadly rounded, truncate at the middle, and is situated much in advance of the frontal foramina. The pariëtal is in contact with the alisphenoid. The squamosal does not extend beyond the vertical line from the base of the paroccipital process.

The infraorbital foramen is above the anterior edge of the third superior premolar, a position only seen elsewhere in the genus *A. trifrons*. The superior border of the orbit is concave and short as in *A. guyotianus*, and not straight and flat as in *A. trifrons*. The frontal foramina are above their middle, and their distance apart goes 4.5 times into the interorbital width. There is a large postpariëtal foramen on the pariëtosquamosal suture, and a large postsquamosal immediately below it. This arrangement differs from that seen in the other species here described, where there are two or three postsquamosals well posterior to the postpariëtal. Mastoid foramen small. There are two palatine foramina on each side of the mouth, one opposite the posterior edge of the second premolar, and one opposite the posterior part of the fourth premolar. The anterior condyloid foramen is large. On one side is a small posterior condyloid, the only occurrence I have met with in the family. The foramen lacerum posterius is not divided into three foramina as in the *A. guyotianus*, but remains open as in the species of *Eucrotaphus* and *Merycochœrus*. It shows its nearer affinity to the first named species, however, in its triradiate outline; and in the three grooves of the side of the bulla, which correspond to two of the three foramina. The *f. lacerum anterius* is not large, and is oblong in shape. The ovale is rather small, and is entirely bounded on the inner side by the pterygoid ala of the sphenoid. The *f. rotundum* is large and rather posterior. It is not bounded below by a transverse shoulder as is seen in the species of Merycochœrus, but is continued into a longitudinal groove, whose

external wall is longer than in any of the other genera of the family, extending to a point half-way between the inferior edge of the foramen and the middle of the last superior true molar tooth. It is curved both inwards and downwards just posterior to the foramen.

The superior molar teeth do not differ from those of *M. guyotianus*, *M. antiquus* and *M. latifrons*. The canines are very robust, and are separated from the first true molar by a considerable diastema.

Measurements.	M.
Length from occipital condyles to line of postglenoid processes	.046
Length from occipital condyles to line of preglenoid border	.060
Length from occipital condyles to line of postfrontal process	.110
Length from occipital condyles to line of canines, inclusive	.220
Length from orbit to canine inclusive	.076
Width of occipital condyles inclusive	.050
" " occiput at paroccipitals	.031
" between otic bullæ	.015
" at postglenoid processes inclusive	.093
" of skull above glenoid surfaces	.110
" " " below orbits	.094
" " " between orbits	.064
" " " at fundus of canine alveoli; about	.029
" " " between last upper molars, inclusive	.080
" " palate at second true molars	.033
" " " " third premolars	.031
" between superior canine	.021
Depth of occiput to foramen magnum	.038
" " " " basioccipital	.057
" " skull at last superior molar exclusive	.050
" " " " first premolar, exclusive	.046
" " zygomatic arch above glenoid facet	.021
Diameters base crown superior canine { anteroposterior	.014
Diameters base crown superior canine { transverse	.012
Length diastema to first premolar	.0185
" premolar series	.0365
" true molar series	.045
Diameters P-m. iv { anteroposterior	.011
Diameters P-m. iv { transverse	.014
Diameters M. i { anteroposterior	.014
Diameters M. i { transverse	.015
Diameters M. iii { anteroposterior	.018
Diameters M. iii { transverse	.021

The skulls of this species came from the John Day bed of the John Day river, Oregon, and were found by Mr. J. L. Wortman. The species was established on an immature individual. The adults show that it belongs to this genus.

COLOREODON Cope.

Proceedings American Philosophical Society, 1879, p. 375.

Superior premolars three, the fourth with two external Vs, no facial vacuities.

The mandibles of the species of this genus are unknown, so that the character of the inferior dentition is unknown. The otic bullæ are also destroyed in all the specimens, so that their character is unknown.

In its reduced dental formula this genus represents one stage of that specialization which Owen has shown, has overtaken all the modern types of Mammalia. In this series this process seems to have stopped at this point, and not to have gone further, as the entire line has come to an end.

The first superior premolar probably exists in a rudimental condition for a short time, and is early shed. The same state of things has been found to exist as an abnormality on one side in the *Agriochœrus guyotianus*, and may be found again, but not so as to invalidate the characters of the genus Coloreodon.

Two well-marked species of this genus have been described, which differ as follows:

Smaller; palatonareal border opposite posterior cusps of second true molar; sagittal crest anterior, commencing opposite optic foramina..... *C. ferox.*

Larger; palatonareal border opposite posterior cusps of third true molar; sagittal crest posterior, commencing opposite preglenoid border..... *C. macrocephalus.*

Coloreodon ferox Cope. Fig. 1, p. 505.

Proceedings American Philosophical Society, 1879, p. 375.

The size of *Oreodon culbertsoni*. Known from one skull from the North Fork of the John Day river, Oregon. C. H. Sternberg.

Coloreodon macrocephalus Cope.

Proceedings American Philosophical Society, 1879, p. 376.

Size of the *Eucrotaphus major*. The typical skull is from the North Fork of the John Day river. A second skull, lacking all the parts posterior to the anterior origin of the sagittal crest, is undistinguishable from the first. It was found at the "Cove" of the John Day river, Oregon. Both were obtained by Mr. J. L. Wortman.

GENERAL CONCLUSIONS.

From what is now known of the history of the Oreodontidæ, the following conclusions may be drawn. These are especially instructive as far as they go, since they involve the causes of the rise, great development, decadence and extinction of one of the best-marked types of Mammalia the world has seen. The history of this type involves more or less the history of the life of the North American continent during the Miocene epoch of Tertiary time. It moreover involves the laws which regulate the vital success of all types of life, and which express the causes of multiplication, of energy, of weakness, and of sterility.

Two lines of the family, the *Oreodontinæ* and the *Agriochœrinæ*, come to light simultaneously in geological time, the White River epoch, or the Oligocene. The latter is a higher type than the former in its more complex fourth premolars, while it is inferior in the non-closure of the orbits posteriorly. It may then be regarded as a parallel line. It has but two generic types, while the Oreodontinæ present us with seven. So far as yet known, the Agriochœrinæ did not continue as long as the Oreodontinæ, as will be shown in tabular form below.

In the progressive modifications of the Oreodontinæ series, the first step was the inflation of the otic bulla (genus Eucrotaphus). This was succeeded by the coössification of the premaxillary bones (genus Merycochœrus). These changes were accompanied by a regular increase in dimensions. The species of Merycochœrus are all of the largest size, and there are no small ones. The smallest species of Eucrotaphus are equal to the largest ones of Oreodon. The fourth genus Merychyus, while it loses none of the points already gained, shows a deficiency in its facial walls where vacuities appear. There is the greatest range of size here: with one species (*M. major*), as large as any of the Merycochœri, we have another as large as the usual Eucrotaphi (*M. sygomaticus*), and several one degree smaller, or as large as the largest Oreodons. In the next genus the facial vacuities have attained to an enormous size. The premolar teeth become smaller, and the weakness of the narrow symphysis of the lower jaw is made up for by its coössification. The size is reduced from equal to the smallest Merychyi, to that of the smallest Oreodons (genus Leptauchenia). In the next stage (genus Cyclopidius) the superior incisors disappear. Finally, the lower jaw is so reduced in front that it loses both incisors and premolars, in spite of its symphyseal coössification (genus Pithecistes).

The species may be thus arranged in accordance with their distribution in time.

White River Epoch. Oreodon gracilis; O. affinis; O. culbertsoni. Eucrotaphus jacksoni; E. major. Agriochœrus antiquus; A. major; A. latifrons.

John Day Epoch. Eucrotaphus jacksoni; E. major. Merycochœrus superbus; M. leidyi; M. chelydra, sp. nov.; M. macrostegus, sp. nov

Agriochœrus guyotianus; A. trifrons, sp. nov.; A. ryderanus. Coloreodon macrocephalus.

North Fork of John Day River Epoch. Eucrotaphus trigonocephalus, sp. nov.; E major. Coloreodon ferox; C. macrocephalus.

Ticholeptus Beds. Merycochœrus montanus, sp. nov.; M. rusticus; M. proprius. Merychyus arenarum, sp. nov.; M. pariogonus, sp. nov.; M. zygomaticus. Cyclopidius simus; C. emydinus, sp. nov. Leptauchenia major; L. decora; L. nitida. Pithecistes brevifacies; P. heterodon; P. decedens, sp. nov.

Loup Fork Beds. ? Merychyus elegans; M. medius; ? M. major.*

The stratigraphic relations of these species may be represented under their generic heads in the following table:

	No. of species.	White River Epoch.	John Day Epoch.	?North Fork Epoch.	Ticholeptus Epoch.	Loup Fork Epoch.
Oreodontinæ.						
Oreodon Leidy.....	3	—				
Eucrotaphus Leidy....	3	—	—	—		
Merycochœrus Leidy ..	7		—	—	—	
Merychyus Leidy.....	6				—	—
Leptauchenia Leidy ...	3				—	
Cyclopidius Cope.....	2				—	
Pithecistes Cope.....	3				—	
Agriochœrinæ.						
Agriochœrus Leidy....	6	—	—			
Coloreodon Cope.....	2		—	—		
	35					

On the Structure of the Skull in the Elasmobranch genus Didymodus.

By E. D. Cope.

(*Read before the American Philosophical Society, March 7, 1884.*)

The genus *Diplodus* was described by Agassiz from specimens of teeth from the European Coal Measures. In America, Newberry and Worthen† have described four species from the Carboniferous of Illinois and Ohio; and I have reported two species from the Permian beds of Illinois and Texas. Recently Mr. Samuel Garman has described a shark, said to have been taken in the Japanese seas, under the name of *Chlamydoselachus*

* The questions refer to the geological age.

† Geology of Illinois, vol. ii.

anguineus, whose teeth, as represented, do not differ generically from those of Diplodus. This is an interesting discovery, indicating that this genus, and not Ceratodus, is the oldest type of vertebrate now known in the living state.

My collections from the Permian beds of Texas include not only numerous teeth, but jaws and crania. Among these I recognize two types of teeth, which I cannot distinguish from those of the *D. compressus* Newb., and *D. gibbosus* Agass. Whether these species belong to the same genus, is a question which I will discuss at the close of this article. I provisionally refer the *D. compressus* to a distinct genus, Didymodus, and will so call it in this article.

The determination of the characters of this genus is a point of much interest The teeth resemble those of the existing sharks more than do those of any other genus of the Palæozoic ages, but the antecedent improbability of the modern type having existed at such an early period of the earth's history, is shown to be well founded by the present investigation, which also throws much light on the question of the general phylogeny of the fishes.

I. Description.

Twelve more or less complete crania of species of Didymodus are in my collection, and one set of jaws with small teeth and part of the cranium attached. One of the crania, unfortunately much broken, exhibits also some large teeth. All were found by the late Jacob Boll in the Permian beds of Texas.

The skull of this species forms a continuum, which, however, displays distinct segments. First, however, as to the tissue of which it is composed. Both on the surface and in transverse fractures, it is more or less finely granular, the granules distinctly visible to the naked eye. These granules are composed of gypsum, as is also the matrix of a darker color in which they lie imbedded. Two hypotheses may be entertained regarding this structure. *First*, These granules may be regarded as the casts of coarse cartilage cells, and the matrix be in the place of the intercellular cartilage, replaced like the woody tissue in petrified wood. *Second*, The granules may be looked upon as replacements of osseous granules, such as cover the chondrocranium of most Elasmobranch fishes, while the matrix may be a replacement of the cartilage. The latter hypothesis is the more probable of the two, for two reasons: First, There is little probability of an unsupported chondrocranium retaining its form sufficiently long to permit the filling of its cells with a mineral deposit. Second, The granular type of ossification is well known in existing Elasmobranchs. It is only necessary to believe that the chondrocranium is penetrated by this kind of ossification. This state of things exists in the jaws also, which I describe later. This structure has already been observed by Kner in the genus Pleuracanthus.

The osseous cranium is abbreviated anteriorly, and elongated posteriorly,

The orbit occupies part of the anterior third of the length. It is bounded in front by an obtuse preorbital process, and posteriorly by a laterally expanded and decurved postorbital process. The latter bears an articular facet on its posterior and inferior face. The top of the muzzle is excavated by a fontanelle which does not extend posterior to a line connecting the preorbital processes.

There is a prominent cup-shaped occipital condyle. On each side of the cranium a short distance anterior to it, is a prominent process extending outwards and a little backwards, which is excavated on its inferior side, but whose posterior side is decurved, so that the inferior concavity looks partially forwards. Into this cavity, and abutting against the decurved posterior edge, is a lateral process of the basal axial bone of the skull, which I take to be homologous with the lateral alæ which occupy the same position in the sharks. Anterior to this junction no doubt the hyomandibular bone was suspended, for I suspect that it was articulated to a small condyle which is wedged into the fissure between the inferior and superior elements described, a centimeter anterior to their posterior extremities. This condyle is a distinct element of a subglobular form.

The interorbital plane is continued posteriorly, bounded on each side by a depression which probably corresponds to the temporal fossa of higher vertebrates. The edges of this plane are thus well within the lateral borders of the cranium. The plane rises a little posteriorly, and is split into two narrow wedge-shaped processes, which project freely upwards and backwards. The rather short remaining part of the roof of the skull has a keel or sagittal crest on the middle line, which descends gradually to the foramen magnum.

The base of the skull forms a continuum from the edge of the large occipital cotylus to the acuminate anterior extremity. The lateral basal alæ are subcylindric, and are separated from the basicranial axis by a fissure for a short distance, and then unite with it. Two or three foramina anterior to this reunion, are in line with the defining fissure just mentioned. The basis cranii sends out a process on each side below the postorbital processes, giving a cross-shape to this part of the base of the skull. Anterior to this point it is free from other elements and contracts to an acuminate apex.

The cranium is segmented, but a clean specimen is necessary to permit the straight sutures to be seen. In the first place, there is a distinct occipital bone, which includes exoccipital and basioccipital elements combined. The latter includes the large occipital cotylus, as in the Rhachitomous batrachian Trimerorhachis, and differs from the structure seen in the Lepidosirenidæ, where exoccipital elements only are present. The occipital extends but a short distance on the inferior face of the axis. It is preceded directly, and without imbrication, by a continuous axial element. If we recognize in the granular character of the tissue evidence of true ossification of the chondrocranium, we have here true continuous sphenoid and presphenoid bones.

Returning to the superior face of the cranium, we observe that the exoccipital elements form a wedge-shaped body, divided on the middle line by suture, with the apex forwards. Traces of this division are figured by Gegenbaur as present in Heptanchus.* Anterior to this the middle of the cranial roof is apparently occupied by another triangular bone with the base posterior and the apex anterior, and concealed beneath the free extremity of the element in front of it. The lateral sutures only are distinguishable, appearing as grooves (fig. 2). This is the pariëtal bone. External to this and the occipital, and filling the space behind as well as anterior to the postero-lateral angle of the pariëtal, is the element which is produced outwards and backwards as already described. Were I describing a true fish, this bone might be intercalare (epiotic) or pterotic. Perhaps it is both combined, or it may be the cartilage bone called by Günther, in Ceratodus, the "tympanic lamina."† The element anterior to the pariëtal is the cartilaginous representative of the frontal, and the fact that it terminates posteriorly in two free processes is significant of the true homology of the bones which terminate in like manner in the crania of the Lepidosirenidæ.‡ In this family and in the Ceratodontidæ these bones are more or less separated on the middle line by the median posterior element. In Ceratodus the separation is wide; in Lepidosiren the interval is uninterrupted, but narrow in front. In Protopterus these elements are in contact on the middle line, but diverge posteriorly. Bischoff, Stannius§ and Günther identify these elements with the frontals in the genera they have described. Huxley‖ calls them supraorbitals, so that it becomes necessary to name the median posterior element a frontopariëtal, as a combination of two bones usually found distinct in fishes. The furcate structure of the frontal cartilage in Didymodus goes to show that the identification by Bischoff and Günther is the correct one. There are also in this genus distinct paired membrane bones which do not take part in the bifurcation in question, and which appear to represent the frontals of Ceratodus. Each of these is a flat, subcrescentic supraorbital plate, which has a concave superciliary border. It is separated by a considerable interval from its fellow of the opposite side. Its anterior extremity is notched by a fossa which I suppose to represent the anteterior (posterior in position) nostril. The ? frontal of the right side is displaced, and appears as a lamina lying on the frontal cartilage, showing that it is a membrane bone. From its relation to the nostril the question arises, whether it be not the homologue of the nasal.

For hyomandibular bone, palatopterygoid arch, and mandibular arch, we have to rely principally on one specimen. On one of the skulls, two

* Ueber den Bau des Schedels der Selachier, 1872, Pl. I.

† Philosophical Transactions of the Royal Society, 1871, p. 511, indicated on the plates by the letter *d*.

‡ *Lepidosiren paradoxa* by Bischoff, Prof. in Heidelberg; Leipsic, 1840.

§ Handbuch der Anatomie der Wirbelthiere; Rostock; Erstes Buch, die Fische, 1854, p. 49.

‖ Anatomy of Vertebrated Animals, 1871, p. 145.

curved rib-like bones lie parallel and divergent posteriorly on the right side of the frontal, in the temporal fossa. I cannot identify them. They are not present on the opposite side. As already described, there is a facet on the infero-posterior face of the postfrontal process. This indicates the point of articulation of the palatopterygoid arch, as it exists in the group Opistharthri of the sharks as defined by Gill, and as is clearly proven by the specimen now to be described.

This includes the entire palatopterygoid and mandibular arches of one side, and the greater part of that of the opposite side, together with a considerable part of the right hyomandibular bone and probable extremity of the ceratohyal. The anterior parts of both jaws support numerous small teeth, which closely resemble those described by Agassiz as belonging to his *D. gibbosus*. They differ from those of the *D. compressus* in their smaller size. The palatine bones do not project much beyond the mandible, which, taken in connection with the form of the muzzle above described, renders it probable that the mouth was nearly terminal.

In the palatopterygoid arch there is no noticeable separation or suture between the palatine and pterygoid elements. The inferior border of the palatine is swollen below the orbit; its superior plate rises into a strong suborbital ala, which is concave externally, with thin superior edge. This edge rises posteriorly, giving the outline an elevated convexity, whose greatest upward prominence is above a point a little posterior to the middle of the jaw, and which probably articulated with the postorbital process of the cranium. Its surface gives indication of an articular surface appropriate to the corresponding one of the cranium. The superior border then descends rapidly to a vertical posterior border, which forms a somewhat prominent rim. This descends to the mandible, forming a regular ginglymus, the mandible bearing the cotylus. The mandible is rather robust; its inferior edge is rather thin, and becomes incurved anteriorly. Its superior border is regular, except that it rises a little at the coronoid region, and is impressed, corresponding with a concavity of the surface, and arch of the border of the pterygoid region, just anterior to the posterior prominent ridge which forms its posterior edge.

The hyomandibular bone is only exposed for its inferior half. It issues from behind the palatopterygoid as a narrow shaft with obliquely truncate extremity.

It is thus evident that the arrangement of the jaws is as in the two exceptional existing genera, Hexanchus and Heptanchus.

The external nostril already referred to, is a distinct, rather small fossa, on the lateral part of the superior face of the muzzle, near the extremity of the osseous portion. It is visible on both sides of the best-preserved specimen. It is continued forwards as a shallow groove. At the apex of the muzzle, is a fossa looking downwards, where roofed on each side by the ? nasal bones, which may represent the posterior nasal cavity. Or the latter may probably be represented by a lateral fossa just in front of the preorbital process. In either case it is evident that the nares are separated,

and that the posterior one cannot be said to be within the oral cavity, as is the case in the known families of the Dipnoi. It is probable that there is a frontoparietal foramen at the posterior bifurcation of the frontal bones, corresponding to the conarium or pineal body of the brain. In a cranium broken across just anterior to the bifurcation, a canal passing forwards and downwards is exposed. There is a foramen, or possibly only a deep fossa on each side of the middle line on the occipito-sphenoid suture. The foramen magnum is rather small and opens upwards. Its border displays no articular surfaces. At the middle of a line connecting the posterior borders of the postorbital processes is a small shallow fossa, or probably foramen, from this there extends on each side backwards and outwards, a shallow groove apparently for a vessel, which terminates at the anterior one of three foramina already mentioned as in line with the fissure which distinguishes the lateral ala of the basicranial axis posteriorly. A similar groove connects the first and second of these foramina, and in one specimen the groove from the median foramen joins this connecting groove. In front of the median foramen is a rather larger one on the median line, situated at the fundus of a short longitudinal groove. It is placed just posterior to a line connecting the preorbital processes. The grooves easily become obsolete by weathering.

II. Affinities.

In determining the systematic position of this animal, it will be convenient to take a survey of the characters of the primary divisions of the fishes. In 1840 Bischoff published the first account of the osteology of Lepidosiren. In this description he called the frontal bones malars with a question, and the parietals frontoparietals. He described the skull as having an os quadratum. In 1854, Stannius in the Handbuch der Zoötomie* correctly determined the frontals and parietals, and stated further that the "lower jaw and hyoid bone articulate directly with continuous processes of the chondrocranium." This appears to be the first correct description of the cranial structure of the Dipnoi. In 1864,† Huxley restated the view of Stannius as to the nature of the mandibular articulation; adopted the opinion of Bischoff that the frontal is a frontoparietal, and took a new position in calling the frontals supraorbitals. He also restates in general, the description of the skull of the Holocephali already given by Stannius.

The system of Johannes Müller, adopted by Stannius, was a great improvement over preceding ones. It embraced, however, the error of including the Holocephali in the same sub-class (Elasmobranchi) with the sharks. This was adopted by Gill in 1861,‡ by Huxley in 1864§ and in 1871.‖ All of these authors adopt at these dates the sub-class Ganoidea.

* Erstes Buch, die Fische, p. 49.
† Elements of Comparative Anatomy, p. 210.
‡ Catalogue of the Fishes of the East Coast of North America, p. 24.
§ Elements of Comparative Anatomy.
‖ The Anatomy of Vertebrated Animals, p. 120.

In 1871* the writer gave the following as the primary divisions of the sub-class Pisces: Holocephali, Selachi, Dipnoi, Crossopterygia, Actinopteri. The Holocephali was raised to an equivalency with the other sub-classes on account of the absence of distinct hyomandibular bone. The Dipnoi were defined by the median pelvic element, by the distichous arrangement of the segments of the pectoral and ventral fins, when present, on a median axis, and by the supposed presence of a distinct hyomandibular bone. The latter definition must be abandoned, for though an ossification exists, it has been shown by Stannius, Huxley and Günther, to be merely a deposit in the continuous chondrocranium. The sub-class Crossopterygia was substituted for the sub-class Ganoidea of Agassiz and Müller, as the latter was believed to have no actual existence as a division of fishes. After comparing the osteology of Polypterus, Lepidosteus and Amia, I remark (p. 320) "It is thus evident that the sub-class Ganoidea cannot be maintained. It cannot be even regarded as an order, since I will show that Lepidosteus, Accipenser, and Amia, are all representatives of distinct orders. I hope, also, to make it evident that Polypterus should be elevated to the rank of a sub-class or division of equal rank with the rest of the fishes and with the Dipnoi, already adopted." The sub-class Ganoidea has not yet fallen into disuse, but there are strong symptoms that it will do so.† Among others I select the following extract from Huxley's paper on the ovaries of the smelt, published in 1883.‡

"As is well known, Lepidosteus presents an example of a Ganoid with oviducts like those of the higher Teleostei; in *Osmerus*, on the other hand, we have a Teleostean with oviducts like those of the ordinary Ganoidei. It is tolerably obvious, therefore, that the characters of the female reproductive organs can lend no support to any attempt to draw a sharp line of demarkation between the Ganoids and the Teleosteans.

"Boas has recently conclusively shown that the same is true of the supposed distinctive character afforded by the conus arteriosus; and it has long been admitted that the spiral valve which has been described in the intestine of *Chirocentrus* is the homologue of that which exists in all the Ganoids, though greatly reduced in *Lepidosteus*. Indeed I am inclined to believe that the circular valve which separates the colon from the rectum in the smelt is merely a last remainder of the spiral valve. Thus, among the supposed absolute distinctions between the Ganoids and the Teleostei, only the peculiarities of the brain, and especially the so-called chiasma of the optic nerves, remain for consideration. My lamented friend Mr. Balfour, in the last of his many valuable labors, proved conclusively that the brain of *Lepidosteus* is, both in structure and development, a Teleostean

* Proceedings Amer. Assoc. Adv. Science, p. 326. Transac. Amer. Philosoph. Soc., p. 449.

† The term ganoid can be used as an adjective to describe the scales already known by that name, and thus be preserved.

‡ Proceedings Zoölogical Society of London, 1883, pp. 137, 138, 139.

brain. But it is singular that no one, so far as I know, has insisted upon the fact, not only that the Teleostean brain is essentially similar to that of the Ganoids, but that it is exactly in those respects in which the Ganoids and Teleostei agree in cerebral structure that they differ most markedly from the Plagiostomi and Chimæroidei.

"With respect to the chiasma of the optic nerves, the exact nature of that structure has not yet been properly elucidated either in the Selachians or in the Ganoids. But, whatever may come of such an investigation, the establishment of the existence of a true chiasma in the Ganoids, and of its absence in Teleosteans, can have but little bearing on the question of their affinities, since Wiedersheim has shown that a simple decussation of the fibres of the optic nerves, as in ordinary Teleosteans, takes place in many lizards."

In 1877* I proposed the following primary divisions of the fishes, and have seen no reason to alter my views as to their value as a correct expression of the affinities and diversities of this class of Vertebrata. The system differs only from that of 1871 in the consolidation of the Crossopterygia and Actinopteri into a single sub-class, the Hyopomata; and in a few corrections of the definitions given. They are as follows:

I. Suspensorium continuous with the cartilaginous cranium, with no hyomandibular. No rudimental opercular bone; no maxillary arch; pelvic bones present; axial series of fore limb shortened, the derivative radii sessile on the basal pieces; axial series of hinder limb prolonged in male.....*Holocephali.*

II. Suspensorium articulated with the cranium; no maxillary arch; no opercular nor pelvic bones; bones of limbs as in the last.....*Elasmobranchi.*

III. Suspensorium rudimental, continuous with cranium, supporting one or more opercular bones; cranium with superior membrane bones; no maxillary arch; a median pelvic element; the limbs supported by segmented unmodified axes.....*Dipnoi.*

IV. Hyomandibular and palatoquadrate bones articulated with cranium, supporting opercular bones; a maxillary arch; no pelvic element; axes of the limbs shortened, the derivative radii sessile on the basal pieces.....*Hyopomata.*

In the definition of the Dipnoi, it is necessary to make the correction in accordance with the best observations on fresh specimens, above referred to, as I have not been able to determine the question from dried specimens in the Hyrtl collection. The suspensorium cannot be properly said to be articulated to the cranium in the sense in which it is said to be such in the Elasmobranchi. In the latter it is articulated by ginglymus; in

*Proceedings of the American Philosophical Society, 1877, p. 25; and in the Annual Reports of the Commissioners of Fisheries of Pennsylvania for 1879-80, p. 67 and 1881-2, p. 111.

the Dipnoi merely by suture or contact, with other cartilage bones. Its character is therefore more nearly that of the Holocephali than of the Elasmobranchi or the Hyopomata.

In the light of the above considerations, to which sub-class must be referred the genus Didymodus? Does it possess a freely articulating hyomandibular bone, and maxillary, palatoquadrate and mandibular arches? The question must be primarily determined by these considerations, since the fins and their supports are unknown to us.

The lateral posterior processes of the skull are in its superior plane, and their extremities do not present an articular facet for the lower jaw. It is improbable that they were continued downwards as cartilage for the former articulation, as in the Holocephali and Dipnoi. Both from the presence of an articular condyle, and from the mechanical necessities of the case, I have little doubt but that there was a freely articulating hyomandibular bone. I have already described this element in fact as visible in a single specimen. The choice is thus limited to the Elasmobranchi and Hyopomata. It is decided in favor of the former by the absence of maxillary arch and of opercular apparatus. So then Didymodus is a shark, in spite of its peculiarities. Kner* speaks of the presence in the nearly allied Pleuracanthus (= Diplodus), of premaxillary and maxillary bones; but this is no doubt a misinterpretation of the homologies, as he says they *articulate with the lower jaw*. In my jaws there is but one bone on each side, a palatopterygoid.

In his researches on the structure of the skulls of sharks, Gegenbaur† shows the different methods of articulation of the palatopterygoid arch in the sub-class Elasmobranchi. In Heterodontus the palatopterygoid arch is attached to the skull throughout by its superior border, anterior to the orbit, but is free posterior to the orbit. In Hexanchus and Heptanchus it is free anteriorly, but articulates by its elevated posterior portion with the postorbital process. In the remainder of known recent Elasmobranchs it is free throughout, and merely in contact in front. These relations are also described by Huxley.‡ Professor Gill utilizes them as definitions of three (of four) primary divisions of the sub-class Elasmobranchi,§ which he names the Opistharthri, (fam. Hexanchidæ); Proarthri (Heterodontidæ); Anarthi (sharks proper); and Rhinæ (Squatinas). According to these definitions, Didymodus must be referred to the Opistharthri. The skull, however, presents other characters which must claim attention. Its

* Sitzungsberichte Wiener Akademie, LV, p. 540.

† Untersuchungen zur Anatomie der Wirbelthiere, Leipzic, 1872.

‡ On the Anatomy of Ceratodus. Proceedings Zoöl. Society of London, 1876, p. 43-4, with figures.

§ Bulletin of the U. S. National Museum, No. 16, 1883, p. 967. Gills fourth group, Rhinæ, does not appear to me to possess the value of the other three, nor are the "Raiæ" and "Pristes" more distinct. I therefore propose that the order Selachii, as defined in the following pages (of the sub-class Elasmobranchi), be divided into three sub-orders: Opistharthri, Proarthri and Anarthri, the latter to include the true sharks, the Squatinæ, the sawfishes and the rays.

reference to the Elasmobranchi is confirmed by the following characters: (1) The nares are not oral. (2) There is a large fontanelle on the summit of the muzzle. (3) There are processes corresponding to the lateral alæ of the basicranial axis.

In another character Didymodus differs from this and all other sub-classes of the Pisces. This is the penetration of the granular ossification throughout the chondrocranium.

In the following characters it agrees with the Dipnoi: (1) The distinct exoccipital, pariëtal, and frontal elements. (2) The occipital cotylus. (3) The posterior bifurcation of the frontal cartilage.

In the following characters Didymodus resembles the Hyopomatous or true fishes: (1) In the basioccipital bone with condyle. (2) In the ?os intercalare or pteroticum. (3) The presence of a distinct element articulating with the proximal end of the hyomandibular. (4) The presence of membrane bones in the position of frontals.

The characters above cited as constituting resemblances to the true fishes, will not, it appears to me, permit the reference of this genus to any of the divisions of sharks established by Prof. Gill. I therefore proposed a new order of the Elasmobranchi* for its reception, with the following name and definition.

A basioccipital bone and condyle. Occipital, ?pterotic, and frontal bones distinct. Supraorbital (or nasal) bones present.....*Ichthyotomi.*

The remaining Elasmobranchi, in which the above characters are wanting, may be termed by way of contrast, utilizing an old name, *Selachii.*

Were it not for the probable presence of the free hyomandibular bone, the order Ichthyotomi might be regarded, in the absence of knowledge of its limbs, as the possible ancestor of the Rhachitomous Batrachia. But as the Batrachia have no distinct suspensorium, or are, to use Müller's convenient term, monimostylic, their origin must still be sought for in some yet undiscovered type of Dipnoi. It is on the other hand very probable that the Ichthyotomi are the group from which the Hyopomata derived their origin. The distinct basioccipital with its two foramina, the superior origin of the hyomandibular, and the superior nostrils, all point towards the true fishes. The tribe of Hyopomata which must be their most immediate descendents, are the Crossopterygia, as I define that division.

I must now compare the Ichthyotomi with such groups of the Hyopomata as they may be supposed to approach most closely. I begin by referring to the marine eels of the order Colocephali. In 1871† I characterized this order as follows: "Pariëtals largely in contact; opercular bones rudimental; the preoperculum generally wanting. Pterygoids rudimental or wanting; ethmoid very wide. Symplectic, maxillary, basal branchihyals, superior and inferior pharyngeal bones, all wanting, except the fourth pharyngeal. This is jaw-like, and is supported by a strong superior branchihyal; other superior branchihyals wanting or cartilaginous."

* American Naturalist, 1884, 413.

† Proceedings American Ass. Adv. Science, xx, pp. 328–334.

The statement "maxillary wanting," is in contradiction to the definition of the sub-class Hyopomata, which asserts the presence of those bones. Stannius* has asserted the absence of the "oberkiefer" in the eel; Günther† describes their presence. As the absence of the maxillary bone would constitute a point of resemblance, if not affinity to the Elasmobranchi, I have reëxamined my material to determine the homologies of the lateral dentigerous bone of the upper jaw of the eels. My specimens of species of the Colocephali include the following from the Hyrtl collection: *Myrus vulgaris; Sphagebranchus rostratus; Moringua rætaborua; Muræna sp.; Muræna unicolor; Muræna sp.; Poecilophis polyzonus*, and *Gymnomuræna tigrina*. The pterygoid bone exists in a rudimental condition in the *Gymnomuræna tigrina*, *Myrus vulgaris*, and one of the species of Muræna; and whether lost in the preparation of the other crania or not, cannot be stated. In the *Anguilla vulgaris* the pterygoid bone is considerably larger, and extends to a point halfway between its base and the extremity of the muzzle. In the *Conger vulgaris* it extends still further forwards, reaching a transverse process of the anterior part of the vomer. No palatine bone appears. The premaxillary bone is not distinguished from the ethmoid in the Colocephali, nor in the Enchelycephali (Anguillidæ, etc.). It is quite possible, therefore, that the external dentigerous bone or upper jaw, in both of these orders, may be the palatine, and the maxillary be wanting. The family of the Mormyridæ appears to furnish the solution. In this group the structure and connections of the pterygoid bone are much as in Conger, and there are in addition distinct premaxillary and maxillary bones. It is clear that in this family it is the palatine, and not the maxillary bone, that is wanting. Similar evidence is furnished by the family Monopteridæ. The definition of all four of the orders, Colocephali, Enchelycephali, Ichthyocephali and Scyphophori must, therefore, embrace this character. The Gymnarchidæ agrees with the Mormyridæ in this respect, and both families have the transverse process of the vomer which receives the pterygoid, as in the genus Conger.‡ The supposed resemblance to the sharks presented by the Colocephali is then not real, and the question as to the point of affinity of the Ichthyotomi to the true fishes remains open as before.

I now refer to the remarkable characters presented by the deep sea fishes of the family Eurypharyngidæ, as recently published by Messrs. Gill and Ryder.§ These authors find the characters of the skeleton so remarkable, that they think it necessary to establish a new order for its reception, which they call the Lyomeri. The definition which they give is the following: "Fishes with five branchial arches (none modified as branchiostegal or pharyngeal) far behind the skull; an imperfectly ossified skull articulating with the first vertebra by a basioccipital condyle alone; only

* Handbuch der Zootomie, Fische 1854, p. 76.
† Catalogue Fishes, British Museum, vol. viii, p. 19.
‡ These transverse processes are enormously developed in Gymnarchus.
§ Proceedings U. S. National Museum, Nov. 1883, p. 262.

two cephalic arches, both freely movable; (1) an anterior dentigerous one—the palatine, and (2) the suspensorial, consisting of the hyomandibular and quadrate bones; without maxillary bones or distinct posterior bony elements to the mandible; with an imperfect scapular arch remote from the skull; and with separately ossified but imperfect vertebræ."

M. Vaillant came to no conclusion as to the affinities of this group; and Messrs. Gill and Ryder remark, "We are unable to appreciate any affinity of Gastrostomus to any Anacanthines, Physostomes, or typical Apods, nor does it seem to be at all related to Malacosteus, which has been universally considered to be a little modified Stomiatid." It is, however, clear to me that the relationships of this family Eurypharyngidæ are to the order Colocephali, and that they represent the extreme degree of the modification of structure which that order exhibits. In other words, the modification of the ordinary piscine type which is found in the Anguillidæ (order Enchelycephali), is carried to a higher degree in the Colocephali, and reaches its extreme in the Eurypharyngidæ. The points of identity between the two groups last-named are so many, that it becomes desirable to ascertain whether they are susceptible of ordinal separation from each other. The characters above given to the order Lyomeri are in fact identical with those which define the order Colocephali, with a few possible exceptions. First, however, I note that the supposed palatine arch, is probably the maxillary, as in the Colocephali, and that it is the palatopterygoid arch which is absent. The five branchial arches exist in the Colocephali, but the three anterior are rudimental, and the basal branchihyal bones of the fourth and fifth are closely united. There are, however, five arches. There is a ceratohyal arch in Muræna and Gymnomuræna, but of very slender proportions. Whether this element is absolutely wanting in Gastrostomus, or whether the first branchial arch is its homologue, remains to be ascertained. Should the last two be coherent as in the Colocephali, we would then have the same number of hyoid arches in both, viz., six. The "imperfectly ossified cranium" is shown in the detailed description given by Messrs. Gill and Ryder, to support the same bones which are found in the Murænoid skull. The degree of ossification of the skeleton does not constitute a basis for ordinal distinction, if the same elements be present. For this reason the perforation of the vertebral centra by the remnant of the chorda dorsalis does not seem to be of ordinal importance.

In the more detailed description, there are a few charecters worthy of notice. First, "The notochord is persistent in the skull for half the length of the basioccipital." This indicates further the primitive condition of the vertebral column, but scarcely gives basis for an ordinal definition. Second (p. 266.), "The neurapophyses are slender, diverging (instead of convergent), cartilaginous distally, and embracing the neural sheaths on the sides, while by the neurapophyses is supported a membranous sheath which roofs over the nervous cord," etc. The nerual canal is well closed above in the Murænidæ, but in the Anguillidæ it is largely

open above. The neurapophyses it is true unite, but at a distance above the neural cord, and as attenuated rods. Third, "There is no vomer developed, but a triangular cartilaginous element pendent from the cranial rostrum affords attachment for the palatine (read maxillary) element anteriorly," etc. This element probably exists in the Colocephali and similarly takes the place of the vomer, only differing in being ossified. I have been accustomed to regard it as the homologue of the bone called ethmoid in fishes.

The character which distinguishes the Colocephali from the Enchelycephali, now that their maxillary and palatine structure are shown to be essentially the same, is found in the hyoid apparatus. In the Enchelycephali, the structure is as in ordinary fishes; there is a glossohyal, and there are basihyals, and axial branchihyals, and superior pharyngeals. In the Colocephali all these elements are wanting, excepting the fourth superior pharyngeal, which has the form of an antero-posteriorly placed dentigerous jaw, which opposes the lateral branchihyal of the fifth arch or, as it is generally called, the inferior pharyngeal. It is evident that the Eurypharyngidæ are more similar to the Colocephali than to any other order in this respect also, but the description of these parts is not yet sufficiently detailed to enable me to determine what difference there may be in this respect, if any. The mobility of the quadrate bone on the hyomandibular cannot be regarded as of great systematic significance, although it is doubtless important in the economy of the fish.

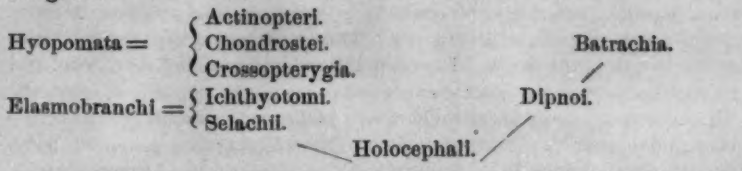
It is then evident that the Eurypharyngidæ belong very near to, if not within, the order Colocephali. Towards the end of their description, Messrs. Gill and Ryder (p. 270), recognize this relationship, but deny that it indicates that this family is "from the same primitive stock as the Murænids." I incline to the belief that it is the ultimate result of the line of development of which the Anguillidæ form one of the first terms, and the Murænidæ a later and more specialized one.

It is therefore clear that the point of relationship of the Ichthyotomi to the true fishes is not to be found in the Eurypharyngidæ or the Colocephali.

In the following point Didymodus resembles Polypterus. The fossa above described as on each side of the basioccipital, is found in Polypterus. There it serves as a place of insertion of a strong ligament on each side, which is attached externally to the epiclavicle, and serves to hold the scapular arch in its place. A similar structure exists in the Siluirdæ, where the ligaments are ossified. It suggests for Didymodus a scapular arch suspended more anteriorly than in sharks, possibly even to the skull.

The genealogy of the fishes will then be as follows, first, however, it is to be understood that in asserting the derivations of one group from another, I mean that in accordance with the rule which I have termed "the doctrine of the unspecialized," the later type in each case is the descendant of the primitive and not the later sub-form of its predecessor. In this way is to be explained the apparent anomaly of regarding the

notochordal sturgeons as descendants of Crossopterygia, whose modern representatives are osseous. The primitive Crossopterygia, and probably even the Actinopteri, were doubtless as cartilaginous as are the existing sturgeons:



In this phylogeny, the Holocephali, which have not differentiated a suspensorium, are regarded as the primitive fishes, although the living representatives display some specialized characters, as, for instance, a membranous gill-cover which conceals the primitive slits. The line to the right continues the monimostylic character and passes into the reptiles, whose primitive types are also monimostylic, as Johannes Müller called them. In the later forms or streptostylicate reptiles of Müller (Lacertilia, Ophidia), the quadrate becomes freely articulated.*

In the left hand series, the Elasmobranchs immediately present us with the free suspensorium or hyomandibular, which is a well-known character of the remainder of the line, the modifications being the addition of separate elements, as the metapterygoid, "quadrate," and symplectic.

The penetration of ossification into the chondrocranium of Didymodus, in regions not ossified in either fishes or batrachia (sphenoid and presphenoid), and into regions not ossified in any vertebrate (frontal and pariëtal cartilages), may be, so to speak, only a local phenomenon, and not indicative of extensive phylogenetic consequences. For if it be so regarded, it evidently proves too much, giving affinities in the base of the skull to the reptiles, and in the roof exhibiting a character more highly developed than any known form of vertebrata.

The Ichthyotomi include, so far as yet known, but one family, the Hybodontidæ of Agassiz. According to that author this family includes four genera, Hybodus, Pleuracanthus, Cladodus and Sphenonchus. It ranges from the coal-measures to the Jura inclusive.

The genus Didymodus may be described as follows:

Frontal plane well defined on each side by the temporal fossæ, and terminating in two cornua posteriorly. Anterior nares on the superior surface of the muzzle. Supraorbital (or nasal) bones well separated on the median line and constituting the only membrane ossification. Teeth with large lateral denticles.

The species *Didymodus compressus* Newberry, may be defined as follows: Skull with massive walls. Form elongate, depressed, the orbit not ex-

* The phylogeny of the Reptilian series can be found in the Proceedings American Association Advancement of Science, xix, 1871, p. 238. The Batrachia are supposed to be their ancestors.

tending behind the anterior third of the length. Basicranial and basifacial axes in one line, flattened, the supraorbital border flat, concave on the edge; postorbital processes obtuse, the temporal ridges commencing with thin posterior border, which they excavate. The ridges then turn, extend parallel posteriorly, terminating in the horn-like processes already described, with a slight divergence. The apices mark the posterior third of the length of the skull. The occipital condyle is wider than deep, and its superior border retreats forwards so as to cause its cup to look upwards. The exoccipital diameter at the foramen magnum is less than that of the basicranial axis, the osseous element of which, probably sphenoid, is recurved on the sides to their middle. The sides of the latter expand a little to meet their lateral alæ. Immediately above their contact is situated the supposed condyle for the hyomandibular element. The basicranial axis is convex opposite the postorbital processes, from the bases of which a concavity separates it. It has a slight median groove at this point. It is much narrower than the interorbital width above. A short distance in front of the postorbital processes it begins to contract, and gradually reaches an acuminate apex. Superior to this apex, commencing posterior to it, the space between it and the supraorbital or nasal elements is occupied by a massive element (? ethmoid) which forms the floor of the nasal median fontanelle.

The surfaces are smooth, but readily weather so as to be granular. The granules are subround, with flattened surface.

Measurements of skull.	M.
Total length of skull to end of frontal bone (No. 1)....	.180
" " " muzzle to orbit; axial.....	.024
" " " skull to postorbital process.....	.058
" " " " to apices of frontal cartilage.....	.117
" " " " to ? pterotic apex (axial).....	.155
Width of skull at prefontals.....	.045
" " " " supraorbital borders.....	.055
" " " " ? pterotic apices.....	088
" " occipital condyle.....	.034
Depth " " "	.025
Measurements of jaws.	
Length of mandibular ramus from cotylus, inclusive.	.145
Depth " mandibular ramus at cotylus.....	.028
" " " " " middle.....	.035
Length " palatopterygoid bone from cotylus, inclusive.	.145
Depth " " " at postorbital articulation.....	.071
Depth of palatopterygoid bone at orbit.....	.035
Length" " " posterior to orbit	.070

A second species has been brought to light by the researches of Mr. W.

F. Cummins in the Permian beds of Texas. Parts of the jaws with two of its teeth are preserved. The lower jaw is distinguished from that of the *D. compressus* by its small transverse as compared with its other diameters. The ramus is quite compressed, and is not thicker at the inferior edge than the superior, and is slightly concave on the inner side. Its external face is nearly vertical. The angle is rounded forwards, and there is no angle behind the cotylus, which is raised above the superior line of the ramus. The cotylus is rather large, and has a shallow anterior superior, and a posterior subposterior facet. There is no indication of a coronoid process. The inferior edge of the ramus is swollen on the outer side, below the anterior border of the condyle, so as to mark with the thickened posterior edge of the ramus a fossa in the position of the masseteric.

The teeth are pecular in the form of the root (Figs. 8–9). This part has no anterior projection, and the posterior portion is a flat, thin-edged plate, wider than long. It carries a button, but no notch. There is a minute median denticle. The form of the root is thus very different from that of the tooth of the *D. compressus* (figs. 5, 7).

Measurements.	M.
Depth of ramus at cotylus (vertical)	.062
" " " 120 mm. anterior to cotylus.	.048
Transverse diameter at the same point	.009
Long diameter (oblique) of cotylus	.031
Diameters of base of tooth { anteroposterior	.011
Diameters of base of tooth { transverse	. 37
Diameters of crown of lateral denticle { anteroposterior	.0048
Diameters of crown of lateral denticle { transverse	.006

I call this species *Didymodus platypternus*. Should the name Didymodus be found hereafter to apply to species of Pleuracanthus, the latter generic name must be used for this species.

III. Historical.

In 1837 Prof. Agassiz (Poiss. foss., iii, 66), described a spine which he believed to have belonged to a fish like the sting-rays, as *Pleuracanthus lævissimus*. The only example was obtained from the Dudley Coal field.

In 1845 Prof. Agassiz (Poiss. foss., iii, 204), made known certain teeth, which he referred to sharks of the family of Hybodonts. Two species were distinguished, *D. gibbossus* and *D. minutus*. Both were obtained from the English Coal measures.

In 1848 Prof. Beyrich (Berichte vernandl. k. Preuss. Akad. wiss., 1848), proposed the generic name Xenacanthus for a German Carboniferous form, referred to Orthacanthus by Goldfuss (1847), but which approached nearer to Pleuracanthus.

In 1849 Dr. Jordan (Jahrbuch für Min. u. Geol., p. 843), described, under the name *Triodus sessilis*, a form subsequently ascertained to be identical with the Xenacanthus.

In 1857 Sir Philip de Malpas Gray Egerton (Ann. and Mag. Nat. Hist., xx, 423), contended that the spines of Pleuracanthus belonged to the same fish as the Diplodus teeth, and that Xenacanthus was likewise referable to the same type.

In 1867 Prof. Kner (Sitzb. k. Akad. wiss. Wien, lv, 540–584), published a memoir, illustrated by ten plates, in which he proved that Diplodus and Xenacanthus were generically identical.

In 1875 Messrs. St. John and Worthen proposed the genus Thrinacodus for the *Diplodus incurvus* and *D. duplicatus* of Newberry and Worthen and the *T. nanus* St. J. and W., from Illinois.

In 1883, in the Proceedings of the Philadelphia Academy (p. 108), I proposed the name Didymodus for the *Diplodus compressus* Newberry.

In Science for 1884, p. 274 (March 7th), I called attention to the close resemblance of the teeth of this genus to those of the recent shark, called by Garman Chlamydoselachus, and expressed my belief in the identity of the two genera.

In the American Naturalist for April, 1884, p. 413, I gave a brief abstract of the characters of the skull of Didymodus, and proposed to regard it as the type of a new order to be called the Ichthyotomi.

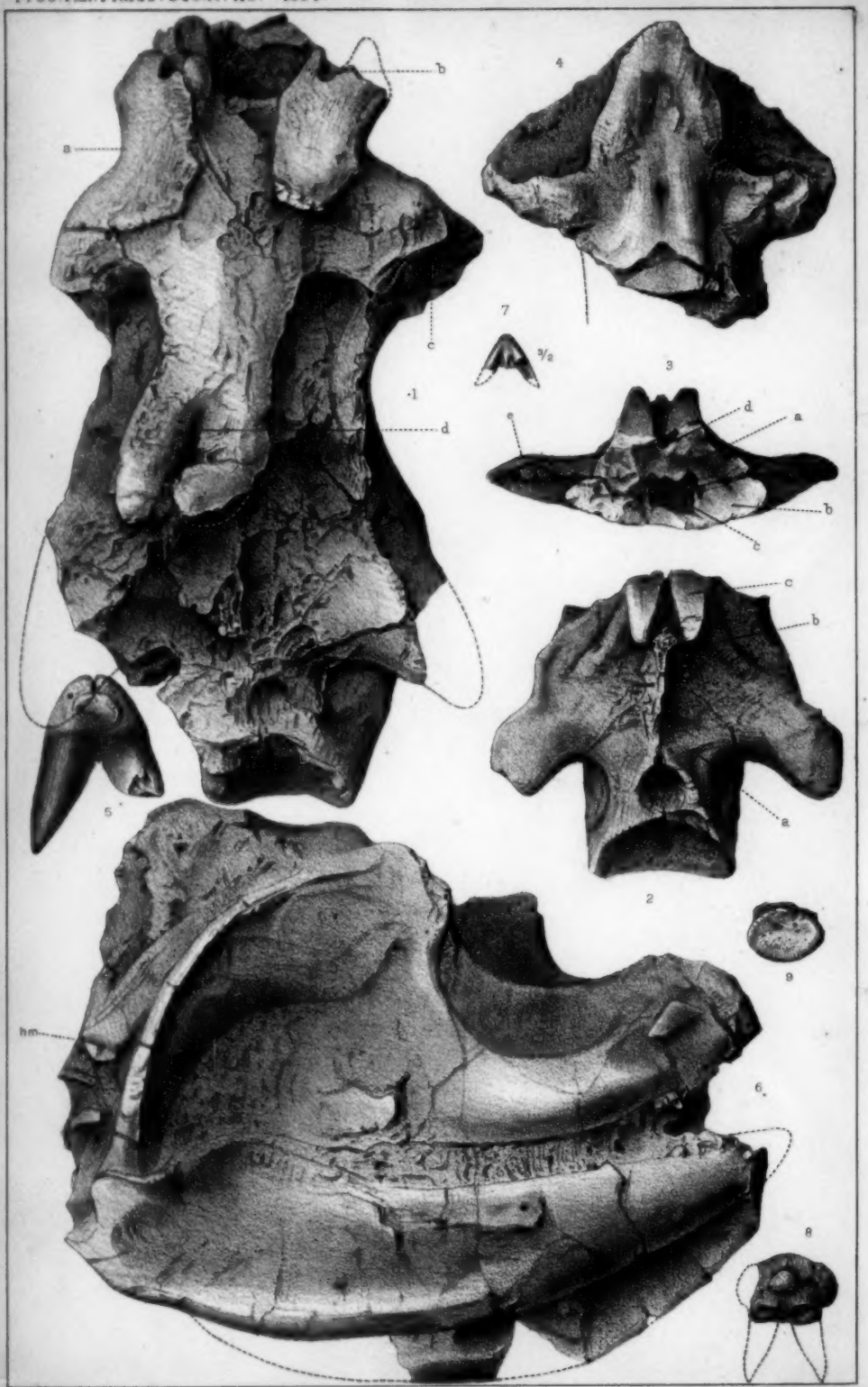
In Science, 1884, p. 429 (April 11), Prof. Gill objects to the identification of the genera Didymodus and Chlamydoselachus; on the ground of the different forms of the teeth. He states that he doubts the pertinence of the two genera to the same order. He points out that the oldest name for Diplodus Ag. is Pleuracanthus Ag., and that the order Ichthyotomi had been already defined and named by Lütken, with the name Xenacanthini.

On these various propositions the following remarks may be made.

(1.) There is no generic difference to be detected, in my opinion, between the teeth which are typical of Diplodus Agass. and Thrinacodus St. J. and W. and the recent Chlamydoselachus. Differences there are, but apparently not of generic value. The identification of the recent and extinct genera rests, as far as this point goes, on the same basis as that of the recent and extinct Ceratodus.

(2.) At the time of my proposal of the name Didymodus, I was not convinced that fishes of this type bore the spines referred to the genus Pleuracanthus Ag. None of the authors cited figure any specimens which present both tricuspidate teeth and a nuchal spine. None of my ten specimens possess a spine. However, Kner describes two specimens as exhibiting both tricuspidate teeth and a spine, and Sir P. Egerton's statements (*l. c.*), on this point are positive. So we must regard Pleuracanthus as the name of this genus, with Diplodus as a synonym.

(3.) Diplodus being regarded as a synomym of Pleuracanthus, it follows that Chlamydoselachus Garm. is distinct, on account of the *different structure of the dorsal fin*, which is single and elongate in Pleuracanthus, according to Geinitz and Kner. The presence of the nuchal spine in Pleuracanthus is also probably a character of distinction, although we do not yet know whether such a spine is concealed in Chlamydoselachus or not.



T. Sinclair & Son, Lith. Phila.

SKULL OF DIDYMODUS.

(4.) The identity of Didymodus (type *Diplodus compressus* Newberry) and Pleuracanthus, may now be questioned. None of the specimens are figured and described by the authors above cited, as displaying an occipital condyle, or posterior frontal cornua. My specimens of *Didymodus compressus* do not exhibit teeth on the roof of the mouth, as Kner describes. There are no spines with the crania, although separate Pleuracanthus spines are not rare in the same beds. The teeth associated with the skulls, moreover, present a button on the superior side of the root (Fig. 5). Agassiz figures teeth of this kind as belonging to the *Diplodus gibbosus*. St. John and Worthen make these teeth typical of Diplodus, and confer the name Thrinacodus on those without the button, a character which I do not think a constant one. The latter name is then probably a synonym of Pleuracanthus. The button-bearing teeth are figured and described by Kner as occurring scattered, and in a somewhat different horizon from that of the Pleuracanthus specimens. In Germany, as in Texas, the button-bearing teeth are the larger. I suspect that the skull I have described represents a different genus from Pleuracanthus proper. This genus will not differ from Chlamydoselachus Garm., in the lack of other evidence; the teeth presenting only specific difference.

(5.) Of course, a study of the anatomy of Chlamydoselachus, which I hope Mr. Garman will soon give us, may reveal differences between that genus and *Didymodus;* but of these we know nothing as yet.

(6.) The order Xenacanthini was proposed by Geinitz (Dyas) for Pleuracanthus, on account of the supposed suctorial character of the ventral fins. This character is supposed by Kner to be sexual. In any case this division, whatever its value, must be subordinated to the order Ichthyotomi, as I define it.

EXPLANATION OF PLATE.

All the figures two-thirds natural size, except fig. 6, which is one-half larger than nature.

FIG. 1. Skull from above, right frontal bone displaced, and its anterior extremity broken off. Posterior apex broken from right frontal cartilage bone. *a*, Frontal or supraorbital bone, that of the right side displaced; *b*, anterior nostril; *c*, postfrontal facet for palatopterygoid; *d*, frontal fissure.

FIG. 2. Posterior part of skull of another individual, from above; *a*, occipital bone; *b*, pariëtal; *c*, a cornua of frontal bone.

FIG. 3. Anterior view of fig. 2, displaying section of brain case; *a*, frontal or pariëtal cartilage bone; *b*, sphenoid; *c*, brain cavity; *d*, frontopariëtal fontanelle; *e*, hyomandibular condyle (? pterotic bone).

FIG. 4. Anterior part of skull from below, of a third individual, displaying orbits and postorbital processes.

FIG. 5. Tooth of *Didymodus compressus* Newb., natural size, posterior view.

FIG. 6. Palatopterygoid and mandibular arches of a fourth individual from right side, with *hm*, hyomandibular.

FIG. 7. Superior tooth of external row, without apices of two of the cusps; from the palatine bone of the specimen represented in fig. 5; one-half larger than nature, anterior view.

FIG. 8. Tooth of *Didymodus platypternus* Cope, nat. size, from above posteriorly.

FIG. 9. Tooth of a second specimen of *Didymodus platypternus* from below.

Photodynamic Notes, IX. By Pliny Earle Chase, LL.D.

(Read before the American Philosophical Society, April 18, 1884.)

411. *Æthereal Oscillation.*

Some readers of the Photodynamic Notes have found a difficulty in applying the laws of pendulum oscillation to the undulations of the luminiferous æther. It is well to guard against the conception of material pendulums, hung in or across the solar system, but it is also well to remember that the modern theories of molecular motion explain the rigidity of steel, and of all other solids, by the rapidity of motion, in ultimate discrete particles. If this view is correct, all changes in molecular movement are probably transmitted in and through the same elastic medium as the undulations of light, and all oscillations are in some way dependent on æthereal oscillations.

412. *Illustrations of Nodal Tendency.*

The well-known experiments of placing bits of paper on vibrating strings, sprinkling sand on Chladni plates, depositing fine powders in transparent musical tubes, and eliciting musical notes from glass vessels which are partly filled with water, illustrate the tendency of all vibrations to drive material particles towards musical nodes. These nodes are subject to the same laws of inertia which determine centres of oscillation in ordinary pendulums. The nodal tendency is greatest where the relative elasticity and the consequent undulatory velocity are greatest. As we know of no other medium in which the ratio of elasticity to density is so great as in the luminiferous æther, we can reasonably look in no other direction for such striking evidences of rhythmic influence as are to be found in cosmical and molecular arrangements.

413. *Æthereal Rotation.*

The supposed properties of the luminiferous æther are so similar, in many respects, to those of ordinary gases, that we may suppose it to act and react on all grosser forms and aggregations of matter. The rotations and revolutions of suns, planets and satellites are not only in harmony

with æthereal undulations, but they are also, as we may reasonably presume, produced by them. If cosmical rotation is dependent, in any way, upon æthereal waves, the reaction of cosmical inertia should produce a tendency to æthereal rotation.

414. *Extent of Rotating Influence.*

It is not unreasonable to suppose that the tendency to æthereal rotation at stellar centres, may be felt at a distance which is at least as great as the modulus of light. That distance in our system is very nearly equivalent to seventy-four times Neptune's mean radius vector. Although the rigidity in a rotating æthereal sphere may seem to be of a very different character from the rigidity of metallic rods and cosmical globes, it must evidently be accompanied by similar tendencies towards gravitating and oscillatory centres.

415. *Kinetic Postulates.*

All modern researches which have been guided by the theory of universal kinetic correlation seem to justify the following postulates:

1. An all-pervading, elastic æthereal medium, the particles of which are subject to gravitating attraction.
2. Consequent cyclic, rhythmic and harmonic tendencies of various kinds.
3. Probable frequency of simple forms of harmony, which are governed by centres of oscillation.
4. Mutual and equal action and reaction between centripetal gravitation and centrifugal radiation.
5. Radiating as well as projectile velocities, which are measured by the sum of cyclical resistances.
6. Correlation and mutual convertibility of light, heat, electricity, gravitation, etc.
7. Tendency of harmonic approximations to become numerically exact, as demonstrated by Laplace in discussing the motions and orbital periods of Jupiter's satellites.

416. *Importance of Reciprocals.*

In some text-books on arithmetic, a few lines are given to the explanation of reciprocals, and the statement is sometimes added, that the reciprocals of an arithmetical progression constitute a harmonic progression. Few, except those who devote themselves to a thorough scientific study of music, ever get any further knowledge of a subject which is full of interest, and which is likely to become of great importance in the future annals of scientific research. In his pamphlet on "Electrical Units of Measurement," Sir William Thomson enlarges upon the want of a unit of conductivity to represent "the reciprocal of the resistances." He says: "It is the conductivity that you want to measure, but the idea is too puzzling; and yet, for some cases, the conductivity system is immensely superior in accuracy and convenience to that by adding resistances in series."

PROC. AMER. PHILOS. SOC. XXI. 116. 3W. PRINTED JULY 21, 1884.

417. *A Universal Want.*

Electricity is the form of force which is now, for many practical reasons, commanding general attention ; but its need of a more satisfactory and systematic study of reciprocal and harmonic activities is no greater than we can find in many other fields of physical research. Ohm's law brings all electrical phenomena so directly within the realm of resistance that Maxwell was inclined to regard electro-dynamics as more fundamental than thermo-dynamics. A full consideration of the subject would require a knowledge of mathematical principles which are somewhat intricate. There are many facts, however, which are so simple and intelligible that they may be easily learned, and a knowledge of them may awaken an interest which will facilitate investigation in every possible field.

418. *Spheral Music.*

We have all heard of the "music of the spheres ;" how many of us understand the literal truth of the statement :

> "There's not the smallest orb which thou behold'st,
> But in his motion like an angel sings."

The music of the spheres, as well as the music of the human voice, or of stringed or brazen instruments, is due to elasticity, which makes successive vibrations follow regular laws, so as to produce rhythmical and pleasing results. The beats of pendulums are governed by some of these harmonic laws and may be represented by harmonic formulas. The luminiferous æther, which is supposed to pervade all planetary and insterstellar spaces, and which Newton suggested as the possible storehouse of gravitation, should, on account of its enormous elasticity, furnish endless illustrations of faultless rhythm.

419. *Confirmation of the Hypothesis.*

We find, in accordance with the foregoing note, that the resistance of the sun to the interstellar vibrations of light produces a series of twenty-seven musical nodes, within the region in which solar attraction predominates over the attraction of the stars. Nine of the nodes are between Mercury and the Sun ; nine are at points which account for the positions of the eight primary planets and of the asteroidal belt ; and nine are between Neptune and the nearest of the fixed stars. The middle node of the middle nine, or the fourteenth node of the twenty-seven, is in the asteroidal belt. These facts, which have been already given in previous notes, are repeated in this connection as indicative of the probability that the æthereal rotation extends much further than was intimated in Note 414, and as giving the most stupendous evidence which has ever been published of the nodal tendencies to which reference is made in Note 411.

420. *Revelation.*

The foundation of all knowledge is revelation, which is always self-evident and infallible. The inspiration of the Almighty giveth understanding. All that we have and all that we are come from Him. In the interpretations of revelation, we are left in some measure to ourselves. While the self-evidence is given to us, we combine, in various ways, premises which we accept on account of their self-evidence or supposed self-evidence; in that combination we are liable to mistakes and fallacies of judgment. All truth is God's, all error is man's. They therefore make a fatal mistake who would set up the decisions of fallible judgment against the revelations which are offered for the acceptance of their own faith, or those which have been clearly apprehended through the faith of others, in truths which have been made self-evident to them.

421. *Fallacy of Agnosticism.*

We have no right to question the assertion of any individual that he does not know God. Neither has any one a right to say that God is unknowable. Receptivity, power, and knowledge, are the three fundamental axioms of all science and of all truth. So far as either of them is finite it is dependent upon something superior to itself. The agnostic, who recognizes a Supreme Power and who fails also to recognize a Supreme Receptivity and a Supreme Wisdom, has but a partial view. If in his teachings he implies, in any way, that human receptivity or human wisdom can be superior to any other receptivity or wisdom, he is guilty of arrogance and cannot shield himself under any assumption of humility. The only power of which we have any practical knowledge, is that of will; and will itself is always directed by purpose. So far as man, through the exercise of his purpose, his will and his intelligence, controls the powers of nature, he is imitating the Supreme control. Although it is true that we cannot "find out the Almighty unto perfection," and although it is also true that we should avoid any narrow anthropomorphism, there is no doubt that the purpose, the will, and the wisdom of man differ from those of the Almighty, not in kind, but only in degree, and that in these respects man has been created in the image of his Maker.

422. *The Oxygen Unit.*

Marignac (*Ann. de Chim. et de Phys.*, March, 1884), in his late re-examination of some of the atomic weights, considers that Prout's law is only approximate, and that, since the numbers which express the atomic weights only represent ratios, there is no reason for taking the hydrogen unit in preference to 16 or 100; but the choice of 16 is justified by its practical advantage. It allows us to represent the atomic weights of the greatest number of elements, and especially of those which are most important, by the most simple possible integers and with the least difference from the rigorous results of experiment. The fact that the atomic weights exhibit

more exact ratios to the oxygen than to the hydrogen unit, appears to have been first pointed out in No. 138 of the foregoing notes.

423. *Universal Rotation.*

The hypothesis that every material particle is endowed with rotation, by which it represents a definite amount of living force, has often been broached. Its probability is strengthened by the magnetic theories* of Arago, Ampére, Barlow, Lecount, Challis, Babbage, Herschel, Christie, Maxwell, Imray, Forbes and others; by my own investigations confirmatory of the hypothesis that "there can be no weight without some degree of momentum;"† by the connection of magnetism with rotation in a magnetic field through Laplace's principle of periodicity (note 333); and by the evidences which are furnished, by notes 413 and 419, of interstellar æthereal rotation, producing nodes which are determined by stellar moduli of light. According to this hypothesis no material particle can be wholly divested of energy, and no particle can ever acquire energy enough to free it from the equilibrating tendencies which spring from the law of equal action and reaction.

424. *Nascent Nebular Rotation.*

The beginning of the transfer of rotation from æthereal particles to cosmical masses, is illustrated by the equivalence of ratios between masses and rupturing distances, in the two ruling globes of the solar system. Taking Bessel's estimate of the mass-ratio of Sun to Jupiter (1047.879), the vector-radii of the two bodies, when in static equilibrium with regard to their common centre of gravity, should be in the same ratio. The projectile energy, which changed the static into an oscillatory dynamic equilibrium, has produced a secular eccentricity, according to Stockwell, of .0608274, the secular perihelion being, therefore, .9391726 of Jupiter's mean radius vector. Dividing the static ratio of vector radii, 1047.879, by .9391726, we get 1115.7469 × Sun's semi-diameter for Jupiter's mean radius vector. Dividing this value by 5.202798, we get 214.4513 for Earth's mean radius vector, which represents a mean solar apparent semi-diameter of 961″.8254. The British Nautical Almanac estimate is 961″.83.

425. *Nascent Resistance.*

Laplace's principle of periodicity, and incipient "subsidence," according to Herschel's modification of the nebular hypothesis, are both exemplified in the equation:

$$(1 - e)\, g_5 t_5 = \sqrt{g_0 r_0}$$

in which e = Jupiter's secular eccentricity; g_0, g_5 = gravitating acceleration at the equatorial surface of Sun and Jupiter, respectively; t_5 = time

*Cited in Proc. Amer. Phil. Soc., ix, 356-8, 367-9, 491; Proc. Roy. Soc., xxii, 352-3, etc.

†Proc. Amer. Phil. Soc., ix, 357, 492.

of Jupiter's half rotation = 17863.25 sec. ; r_0 = Sun's semi-diameter.

Hence $\sqrt{g_0 r_0} = 2\pi \times 214.4513^{\frac{2}{3}} r_0 \div 31558149 = .0006252614\, r_0$.

$$g_0 = .0000003909518\, r_0$$
$$g_5 = .00000003727\, r_0 = .09533064\, g_0$$
$$r_5 = .10005233\, r_0$$

426. *Nascent Centre of Condensation.*

The incipient subsidence of Jupiter, as indicated by the factor $(1 - e)\, g_5$, coöperates with solar attraction in the formation of a belt of maximum condensation. Accordingly, the second planetary mass, in regard to the simplicity of harmonic relations, is Earth, which occupies the centre of the dense belt. Its distance from the Sun and its mass may be found by means of the equation

$$\sqrt{(1 - e)\, g_5 r_5} = (\rho_5 \div \rho_3) \sqrt{g_3 r_3}$$

The mean radius vector is designated by ρ, Jupiter and Earth being indicated by subscript $_5$ and $_3$ respectively. We have, therefore,

$$g_3 = .00607723 \text{ miles}$$
$$r_3 = 3962.8 \text{ miles}$$
$$\sqrt{g_3 r_3} = 4.90743 \text{ miles}$$
$$\rho_5 \div \rho_3 = 5.202798$$
$$\sqrt{(1 - e)\, g_5 r_5} = .09464615 \sqrt{g_0 r_0} = .0000591786\, r_0$$
$$r_0 = 431445.64 \text{ miles}$$
$$\rho_5 = 214.4513\, r_0 = 92524100 \text{ miles.}$$
$$\sqrt{g_0 r_0} = 269.766 \text{ miles}$$
$$m_0 \div m_3 = 328997$$
$$r_5 = 10.893\, r_3$$

427. *Nascent Nodal Harmonies.*

The formation of a belt of maximum condensation, by the action and reaction of subsidence and rotation between the two principal masses of the system, establishes the conditions which are requisite for nodal harmonies of various kinds. One of the simplest harmonic series is $\frac{2}{1}$, $\frac{2}{2}$, $\frac{2}{3}$, etc. The centre of linear oscillation adds its influence to the natural rhythmic tendencies of the second of these nodes. Both the moment of rotary inertia of a thin spherical shell and the nodes of aggregating collision in condensing nebulæ* also introduce the factor $\frac{2}{3}$, and the moment of a rotating æthereal or other homogeneous sphere introduces the factor $\frac{2}{5}$. Moments of inertia vary as distances of projection against uniform resistance ; we may, accordingly, look for the frequent recurrence of the factors $\frac{2}{3}$ and $\frac{2}{5}$, in the harmonic rupturing nodes of condensing and rotating nebulæ, especially in the neighborhood of the most important centres of condensation.

*Proc. Am. Phil. Soc., xvii, 99.

428. *The Sun-Earth Balance.*

The situation of Earth's orbit, between the orbit of Jupiter and the Sun, introduces tendencies to condensation and rotation of the character referred to in the foregoing note. The action and reaction of æthereal waves, between the principal centres of attraction and of condensation, have produced an amount of gravitation, at the earth's equatorial surface, which is sufficient to give a circular orbital velocity of $\sqrt{gr} = 4.90743$ miles per second. The linear oscillation of the Earth around the Sun, as well as the centre of rotary inertia for a superficial film of condensation or of luminous undulation in the orbit of Mars, multiplies this energy by $\frac{4}{3}$; the rotary æthereal oscillation of a sphere which has its limit in the asteroidal belt also multiplies the energy by $\frac{4}{3}$. Accordingly, if the Earth's orbit was always circular, its velocity of revolution, as thus determined, would be $\frac{4}{3} \times \frac{4}{3} \times 4.90743 = 18.40286$ miles per second. There are 31558149 seconds in a year, therefore the Sun's distance should be, if Earth's orbit were always circular, $18.40286 \times 31558149 \div 2\pi = 92430800$ miles. This is probably correct within less than $\frac{1}{3}$ of one per cent. (See Note 434.)

429. *Accuracy of Harmonic Method.*

The above method of estimating the Sun's distance is the shortest which has ever been published. I believe that it is also the most accurate if proper allowance is made for orbital eccentricity, for the following reasons:

1. If the hypothesis of an all pervading luminiferous æther is true, all its cyclical movements must be rhythmic, or harmonic, the various forms of rhythm being governed by various centres of oscillation.

2. The simplest kinds of oscillatory motion, in cosmical bodies, are linear and spherical.

3. Laplace showed, in discussing the motions of Jupiter's satellites, that whenever there are tendencies to simple numerical relations, in planetary arrangements, all the forces of the system combine to make those tendencies exact.

4. The Sun is the principal centre of attraction, and the Earth is the principal centre of condensation in the solar system.

430. *Rhythmic Weight of the Sun.*

The Sun can be weighed by its musical rhythm with a corresponding facility. Orbital velocities vary inversely as the square root of the distance from the centre of gravity. Any two attracting bodies bear the same ratio to each other as the distances at which they would communicate equal orbital velocities, to particles which revolve about the centre of gravity of the attracting bodies. Hence we have:

Earth's Radius Vector. Earth's Radius.

$$92430800 \times (\tfrac{4}{3} \times \tfrac{4}{3})^2 : 3962.8 : : 328002 : 1.$$

In other words the Sun would weigh 328002 times as much as the Earth, if Earth's orbit were always circular.* The remarkable accordances among the various harmonic estimates which are deduced from the correlations of mechanical, electrical, chemical, luminous and other forces, indicate an amount of probable error which is much smaller than those of ordinary astronomical estimates.

431. *Lunar Mass. First Estimate.*

Ferrel (*Methods and Results*, p. 20) gives 7989 metres as the height of the homogeneous atmosphere. The equilibrium of atmospheric elasticity, between the mutual interactions of Earth and Moon (Notes 8, 316), gives the following proportion :

$$(20000000 \div \pi) : 7989 : : r_3 : .0012549 r_3 : : (\pi^3 \times 80.74) : 1$$

432. *Lunar Mass. Second Estimate.*

The estimates of the height of a homogeneous atmosphere differ for different latitudes and for slight variations in the elements of the calculation. It may, therefore, be more satisfactory to deduce the Moon's mass from the simple principles of oscillation.

From Notes 8, 162, 246, we find :

$$l = g\left(\frac{t}{\pi}\right)^2 = \frac{32.08776}{5280} \times (43082.04)^2 \div \pi^2 = 1142874 \text{ miles}$$

for the length of Earth's theoretical pendulum. From this equation we deduce the ratio of Earth's mass (m_3) to Moon's mass (μ), by the proportion :

$$\rho_3 : l : : m_3 : \mu.$$
$$92524100 : 1142874 : : 80.957 : 1$$

433. *Earth's Secular Eccentricity.*

The harmonic relations of the Earth and Moon are still further shown by the evidences of original terrestrial projection before the Moon separated from the Earth. If we designate Earth's secular perihelion radius vector by ρ'_3, we have the proportion, $g_0 r_0 (m_3 + \mu) : (g_3 t_3)^2 m_3 : : \rho_3 : \rho'_3$.

In other words, the orbital vis viva of original solar projection, for the combined masses of Earth and Moon, is represented by the mean radius vector, while the limiting oscillatory vis viva of the Earth alone is represented by the radius vector of secular perihelion. Substituting in the above proportion the harmonic values which we have already found, we have

$$269.766^2 \times 81.957 : 261.8194^2 \times 80.957 : : 1 : .930462$$

this gives, for Earth's secular eccentricity, .069538.

Stockwell's estimate of this eccentricity for the value of Earth's mass which we have deduced from its harmonic oscillation is .06901. The dif-

* See Note 434.

ference between his perihelion radius vector and the corresponding harmonic radius is less than $\frac{1}{17}$ of one per cent.

434. *Correction for Secular Eccentricity.*

In Note 428, Sun's distance was estimated upon the hypothesis that Earth's orbit was circular. The mean distance, however, may be considered as having been established at the time of original rupturing projection, or, in other words, at secular perihelion. The circumference of an ellipse is $2\pi a\left(1-\frac{1}{2^2}e^2-\frac{1^2.3}{2^2.4^2}e^4-\frac{1^2.3^2.5}{2^2.4^2.6^2}e^6, \text{ etc.}\right)$

Substituting the theoretical value $e = .06954$, this becomes $2\pi a \times .99879$. The corresponding value of Earth's mean radius vector is $92430800 \div .99879 = 92542790$, which differs by less than $\frac{1}{17}$ of one per cent, from the value which was deduced in Note 426, from the incipient subsidence of Jupiter. The corresponding value of $m_0 \div m_3$ is 329196.

435. *Twin Planets.*

Action and reaction, in a system which is fundamentally dependent upon two largely preponderating bodies, may naturally lead to a grouping in pairs. Laplace's modification of the nebular hypothesis, which supposes that the first ruptures are in the form of rings or belts, and Herschel's hypothesis of subsidence until the acquired velocity becomes rupturing, also favor the simultaneous formation of companion perihelion and aphelion planets. Accordingly, we find two supra-asteroidal groups, Neptune-Uranus, Jupiter-Saturn, and two infra-asteroidal, Mars-Mercury, Earth-Venus. The grouping in the belt of greatest condensation indicates a double tendency; Earth-Venus representing influences which appear to have orignated in the Sun, while Mars-Mercury seem to be more specially referable to activities at the centre of condensation, than to those at the centre of nucleation.

436. *Mass Relation of Jupiter and Saturn.*

The discovery, by Prof. Stephen Alexander, that the masses of Jupiter and Saturn are nearly in the inverse ratio of the squares of their mean vector-radii, was the first step towards a demonstration of the fundamental principles of harmonic astronomy. This ratio represents the moments of æthereal or nebular rotary inertia for the two planets, respectively. The closeness of the approximation is shown by the proportion

$$5.202798^2 : 9.53852^2 :: 104.879 : 3522.3.$$

Hall's estimate of Sun ÷ by Saturn is 3482; Bessel's 3501.6; Leverrier's 3512. The greatest difference between either of these estimates and Alexander's approximation is only about $1\frac{1}{2}$ per cent, the least difference is less than $\frac{1}{2}$ of one per cent. I know of no other mass-approximations which rest upon purely rhythmical laws, except my own.

437. *Mass-Relation of Earth and Venus.*

The simplicity of the harmonic mass-relations between Sun and Earth, as well as between Jupiter and Saturn, increases the likelihood of similar relations, which are equally simple, between Earth and Venus; but the wide range of discrepancy among the estimates of different astronomers makes it somewhat difficult to ascertain what rhythmic influence has prevailed. Stockwell's estimate of Venus's mass is about .945 of Earth's mass; Hill's is only .831; Leverrier's mean of two estimates, .872. The value which would give Earth and Venus equal orbital momenta is .85049. We may, therefore, claim a great probability for the proportion, $m_0 : m_2 :: (329196 \div .85049 = 387066) : 1$.

438. *Mass-Relation of Neptune and Uranus.*

In the exterior twin planet belt, we find a harmonic mass relation which is no less striking than those that have already been given. It is especially interesting, as pointing to an early stage of nebular condensation, as well as to a blending of external and internal influences which accounts for retrograde satellite rotation and revolution. The gravitating accelerations, which are due to the actions and reactions between two cosmical masses, are proportioned to the respective masses. The vis viva of gravitating subsidence $\left(\frac{m\,v^2}{2}\right)$ is, therefore, proportioned to the cube of the masses. We find, accordingly, that

$$m_8^3 : m_7^3 :: \rho_8' : \rho_7.$$

In this proportion ρ_8' represents the locus of incipient subsidence, or secular aphelion of Neptune, while ρ_7 represents the mean radius vector of Uranus. The values which satisfy this proportion are very exact, as will be seen by the following comparison:

	Harmonic.	Newcomb.
Sun + Neptune	19372.86	19380 ± 70
Sun + Uranus	22603.33	22600 ± 100

439. *Mass-Relation of Mars and Mercury.*

The Earth appears to have exercised an influence upon the two exterior planets of the belt of greatest condensation, analogous to that which the Sun has exercised upon Neptune and Uranus. We find, accordingly,

$$m_4^3 : m_1^3 :: \rho_4 : \rho_1.$$

In this proportion, if we let ρ_4 and ρ_1 represent the mean distances of Mars and Mercury, respectively, the mass of Mars would be 1.5789 times that of Mercury. Adopting Hall's estimate of Sun + Mars = 3093500, we find Sun + Mercury = 4884366. Encke's estimate is 4865751. These estimates are based upon the hypothesis that Sun + Earth = 354936. If we substitute the harmonic value, 329196, we get Sun + Mars = 2869151; Sun + Mercury = 4530150.

440. *Linkage of Earth and Neptune.*

It was shown in Note 428 that Earth's mass may be harmonically deduced from Sun's mass through its limiting value of circular orbital velocity. Neptune's mass may be deduced from Earth's through the corresponding limit of orbital time. We have, accordingly, $m_s : m_\varepsilon :: t_\alpha : t_\beta ::$ 16.98 : 1. In this proportion $t_\alpha = 2\pi\sqrt{\frac{r}{g}}$; t_β = a sidereal day.

441. *Earth's Oblateness.*

The importance of Earth's position, at the centre of the belt of greatest condensation, is further shown by the fact that its centrifugal force of daily rotation, by which it is harmonically connected with Neptune, has also determined its oblateness. For we find that $(t_\alpha + t_\beta)^2 = 288.4$. Listing's estimate (See Note 249) is 288.5.

442. *Linkage of Earth and Uranus.*

Another interesting connection between the dense belt and the outer twin-planet belt, is shown by the proportion, 365.2565 : 338.2183 : : ρ_ε' : ρ_ε. In this proportion, 338.2183 is the distance, measured in Earth's semi-diameters, at which a satellite particle would revolve in a solar year; ρ_ε' is the secular aphelion distance of Uranus, while ρ_ε is its mean distance. This relation is also interesting because the aphelion of the 33.25 year meteoric belt is in the orbit of Uranus, and because a ray of light would traverse the same meteoric orbit in the time of one solar rotation. The proportion gives, for the secular aphelion of Uranus, 1.07994. Stockwell's estimate is 1.07797.

443. *Another Linkage of Earth and Jupiter.*

In notes 425 and 426, the gravitating accelerations of Earth and Jupiter were shown to be harmonically related to each other, as well as to the gravitating acceleration of the Sun. The moon furnishes another harmonic link, which is shown by the equation

$$60.2778 \times 5.202798 \times 1047.879 = 328629.$$

In this equation 60.2778 is von Littrow's estimate of Moon's mean distance in equatorial semidiameters of the Earth; 5.202798 is Jupiter's mean distance, in Earth's mean vector radii; 1047.879 is the quotient of Sun's mass by Jupiter's mass; 328629 is, within less than $\frac{1}{3}$ of one per cent, the harmonic quotient of Sun's mass by Earth's mass.

444. *The Meteoric Theory of World Building.*

Proctor (*North American Review*, May, 1884) criticises the theory of Olbers, which has been lately advocated by Herbert Spencer, and considers that the asteroidal belt has been formed by meteoric influence, in connection with the attraction of Jupiter, rather than by the explosion of any primitive planet. In many of the foregoing notes there has been evidence

of influences which may be regarded as meteoric. Indeed, Herschel's subsidence-theory recognizes the continual activity of such influences, provided we consider every particle which is falling towards the sun as meteoric. If we still further regard the luminiferous æther as material, we may consider ourselves as living in a condensing and rotating nebula.

445. *Linkage of Sun, Earth, Jupiter and Saturn.*

The influence of simple primitive subsidence, which was so strikingly exemplified in the mass-ratios of Neptune and Uranus (Note 438), is no less evident in the four important cosmical bodies which represent, respectively, the chief centre of nucleation (Sun), the chief centre of condensation (Earth), the primitive nebular centre (Jupiter), and the centre of inertia of the primitive planetary system (Saturn). This influence is shown by the equation

$$\text{Sun} \times \text{Earth} \times \text{Saturn} = \text{Jupiter}^2.$$

Substituting in this equation the harmonic ratio of Sun to Earth (329196) and Bessel's estimate of Sun ÷ Saturn (3501.6), we get for Sun ÷ Jupiter 1048.5.

446. *Saturn's Secular Eccentricity.*

The mutual actions and reactions, among the four cosmical masses which were introduced into the foregoing note, are still further shown by the connection of the orbital periods of Earth and Jupiter with the secular eccentricity of Saturn.

This connection is shown by the proportion

$$4332.5848 : 365.2565 :: 1 : .0843045.$$

Stockwell's estimate of Saturn's secular eccentricity is .0843289.

This differs by less than $\frac{1}{3\frac{1}{4}}$ of one per cent from the harmonic estimate.

447. *Primitive Phyllotactic Relations.*

The centre of a nebula which is bounded at opposite extremities of its diameter by the secular aphelia, or loci of incipient subsidence, of Neptune and Uranus, according to Stockwell's estimate, is 4.8952. This differs by less than $\frac{1}{5}$ of one per cent from Jupiter's secular perihelion, or locus of incipient nebular rupture. The mass of Neptune is approximately $\frac{3}{2}\frac{1}{4}$ of Earth's harmonic mass. Uranus is almost precisely $\frac{5}{13}$ of the Uranus-Neptune belt. Saturn is almost precisely $\frac{5}{13}$ of the Jupiter-Saturn belt. The numbers $\frac{1}{2}$, $2 \times \frac{3}{13}$, $\frac{3}{13}$ and $\frac{3}{13}$ are all phyllotactic. The values which fully satisfy these mass relations are

Sun ÷ Neptune	19352.76
Sun ÷ Uranus	22578.22
Sun ÷ Saturn	3490.71
Sun ÷ Jupiter.	1047.21

448. *Phyllotaxy in the Asteroidal Belt.*

Kirkwood (Proc. Amer. Phil. Soc., xxi, 266) in discussing the gaps and clusters of the Asteroidal belt, says: "In three portions of the ring the clustering tendency is distinctly evident. These are from 2.35 to 2.46, from 2.55 to 2.80, and from 3.05 to 3.22; containing forty-three, ninety-six and forty asteroids, respectively. We have thus an obvious resemblance to the rings of Saturn; the partial breaks or chasms in the zone corresponding to the well known intervals in the system of secondary rings." He accounts for the gaps by the periodic harmonic perturbations of Jupiter, but he gives no explanation of the clustering tendency.

If we take $\frac{5}{11}$, $\frac{1}{2}$, and $\frac{8}{9}$ of Jupiter's mean distance, we have 2.401, 2.601, 3.252. The numbers $2 \times \frac{5}{11}$, $\frac{1}{2}$, and $\frac{8}{9}$ are all phyllotactic. The first of the clusters, $\frac{5}{11}$, seems to indicate a harmonic connection with the primitive rupture of the Uranus-Neptune belt which was pointed out in the foregoing note.

449. *Constant of Aberration.*

Magnus Nyrén has published, in the Memoirs of the St. Petersburg Academy, a valuable paper on the determination of the constant of aberration. A summary of his results is given by A. M. W. Downing, in *The Observatory*, vi, 365. The value which has long been accepted by astronomers is 20″.445. Struve discussed the possible sources of error, some years after the publication of his memoir, and adopted the value 20″.463. Nyrén deduces, from three different sets of observations at Pulkowa, 20″.492 ± 0″.006, which Downing thinks "must be an extremely accurate value of this important constant, and will probably have to be considered final until it can be corrected by an equally accurate and extensive series of determinations made in the southern hemisphere. Such a determination is, at the present time, a desideratum in astronomy."

450. *Succession of Harmonic Mass Influences.*

According to the foregoing notes, the first harmonic influence in the determination of relative planetary masses seems to have been that of simple subsidence, represented by the cubes of masses. Next was the simple product of mass by distance, representing the beginning of the change from static to rotary equilibrium. Then came the product of mass by the square of the distance, representing nebular rotary inertia. This was followed by the quotient of mass by the square root of distance, representing simple orbital momentum. These relations seem so natural and so important that it may be well to give the calculations in detail, for future reference, and also to extend those calculations to the most important linkages which have been indicated among the different planetary and satellite belts.

451. *Simple Subsidence.*

There are three planetary illustrations of the determination of mass by simple subsidence:

1. In the Neptune-Uranus belt (Note 438) the mass of the belt (m_1 +

m_8) and the mean eccentricity of the outer or subsident member are so influenced by the change of centripetal into tangential orbital motion that we find

$$\pi^2 (1 + e_8) (m_7 + m_8) = m_5.$$

According to Stockwell, Neptune's mean secular eccentricity, $e_8 =$ .0100389. Hence we derive the data for the following calculation:

	30.46955	1.4838661	1
	19.183581	1.2829297	2
$\frac{1}{2}$ (1 — 2)	1.1667527	.0669788	3
π^2		.9942998	4
$1 + e_8$		.0043381	5
		3.0203111	6
(4 + 5 + 6) = log. $1 \div (m_7 + m_8)$		4.0189490	7

log. (3) representing the ratio of $m_8 : m_7$, log. $m_8 =$ log. $\frac{1.1667527}{2.1667527}$ + (7), and log. $m_7 =$ log. $\frac{1}{2.1667527}$ + (7),

2.1667527		.3358093	8
(7 + 8) = $1 \div m_7$		4.3547583	9
(9 — 3) = $1 \div m_8$		4.2877795	10

2. In the actions and reactions of the chief centres of nucleation (Sun), condensation (Earth), nebulosity (Jupiter), and planetary inertia (Saturn), the mass relation arises which is given in Note 445.

$1 \div m_3 =$ 329196		5.5174544	11
$1 \div m_6 =$ 3501.6		3.5442665	12
$\frac{1}{2}$ (11 + 12)		3.0205736	13

3. In the Mars-Mercury belt, as modified by solar and terrestrial action (Note 439).

$\rho_4 =$	1.5236898	.1828960	14
$\rho_1 =$	.3870087	T.5878218	15
(14 — 15)		.5950742	16
$\frac{1}{2}$ (16)	1.5789	.1983581	17
	3093500	6.4904501	18
(17 + 18)	4884366	6.6888081	19
	354936	5.5501499	20
(18 + 11 — 20)	2869151	6.4577546	21
(19 + 11 — 20)	4530150	6.6561126	22

452. *Change of Static to Rotary Equilibrium.*

The following logarithms represent the influence of the change from static to rotary equilibrium as explained in Note 424.

$1 \div m_5 =$	1047.879	3.0203111	23
ρ'_5	.9391726	T.9727454	24
(23 — 24)	1115.747	3.0475657	25
ρ_5	5.202798	.7162339	26
ρ_2	214.4513	2.3313288	27
$r =$	206264″.806247	5.3144251	28
(28 — 27) $r_0 =$	961″.8254	2.9830963	29

453. *Mass of Saturn.*

Dr. Meyer's estimate of $m_0 \div m_6$ (*The Observatory*, vi, 279), is 3482.93 $\pm$ 5.5. This is nearly identical with Hall's value, as given in Note 436. Meyer includes the rings, estimating their mass as equivalent to $\frac{1}{119.1} m_6$. Bessel's estimate was $\frac{1}{118}$. If we omit the rings, $m_0 \div m_6$ becomes, according to Meyer, 3512.2, which is substantially identical with Leverrier's value (3512). Substituting in Alexander's harmony we get, for Saturn's mean distance, $9.52513\rho_3$, which differs by less than $\frac{1}{4}$ of one per cent from the generally accepted distance.

	3512.2	3.5455792	30
(26) + ½ (30 — 23)	9.52513	.9788709	31

454. *Orbital Momentum.*

The logarithms which represent orbital momentum for Earth and Venus (Note 437) are as follows:

	.7233323	T.8593379	32
½ (32)	.85049	T.9296690	33
(11 — 33)	397066	5.5877854	34

Notes 451–4 give simple harmonic approximations to all the masses of the eight primary planets. I think this is the first publication in which a uniform scale has been adopted for all the planets, and I submit it fearlessly for comparison with any estimate which has been based on ordinary astronomical data.

455. *Linkage of Earth and Jupiter.*

We are now prepared for a systematic examination of the linkages among the different belts. In note 425 we found that the gravitating energies, at the chief centres of nucleation and of nebulosity, are so connected as to give the equation:

$$(1 - \epsilon)\, g_5\, t_5 = \sqrt{g_0\, r_0}.$$

The value of $\sqrt{g_0\, r_0}$ may be found by the following logarithms:

2π		.7981799	35
½ (37)		3.4969932	36
31558149		7.4991115	37
(35) + (36) — (37)		$\bar{1}$.7960616	38
2 (38)		$\bar{7}$.5921232	39
$t_5 =$	17863.25	4.2519605	40
(38) — (24) — (40)		$\bar{3}$.5713557	41
(41) — (39)		$\bar{2}$.9793325	42
½ (— 23 — 42)		$\bar{1}$.0002282	43

456. *Earth's Mean Radius Vector.*

The mean radius vector of the chief centre of condensation is harmonically found by the methods of Notes 428 and 434.

$g_3 = .00607723$ miles.	$\bar{3}.7837055$	44
$r_3 = 3962.8$	3.5980022	45
$\sqrt{g_3 r_3} = 4.90743$	.6908538	46
$\frac{5}{8} \times \frac{1}{3}$	.5740313	47
(46) + (47)	1.2648851	48
(48) + (37) — (35)	7.9658167	49
.99879	$\bar{1}$.9994742	50
(49) — (50)	7.9663425	51

The value of $m_0 + m_3$, which represents this mean distance, may be found by the formula:

$$4\left(\frac{\rho_3}{r_3}\right)^3 \pi^2 r_3 \div (g_3 \times 31558149^2) = m_0 + m_3$$

$$3\,(51 - 45) + 2\,(35) + (45) - (44) - 2\,(37) = (11)$$

457. *Second Linkage of Earth and Jupiter.*

The linkage between the superficial gravitating energies of Earth and Jupiter, which is shown in Note 426, may be computed as follows:

$\frac{1}{2}(24 + 42 + 43)$	$\bar{2}$.9761030	52
(38 + 52)	$\bar{5}$.7721646	53
(26 + 46 — 53)	5.6349261	54
(27 + 54)	7.9662549	55
(38 + 54)	2.4309877	56
2 (56 — 46) + (54 — 45)	5.5171917	57
(43 + 54 — 45)	1.0371521	58

458. *Other Terrestrial Linkages.*

The linkage of Earth, Moon and Jupiter, which is represented in Note 443, introduces the following logarithms.

60.2778		1.7801574	59
(59 + 26 + 23)		5.5167054	60

The linkage of Earth and Neptune (Note 440) with Earth's oblateness gives the following logarithms:

$\frac{1}{2}(45 - 44)$		2.9071484	61
(61 + 35)		3.7053283	62
86164.08		4.9353263	63
(63 — 62)	16.9824	1.2299980	64
(11 — 64)	19384.58	4.2874564	65
2 (64)	288.4	2.4599960	66

The linkage of Earth and Uranus, Note 442, gives the following logarithms:

365.2565		2.5625979	67
338.2183		2.5291971	68
(67 — 68)	1.07994	.0334008	69

459. *Moon's Mass and Earth's Eccentricity.*

The harmonies of lunar mass and Earth's orbital eccentricity (Notes 431–3) introduce the following logarithms:

π		.4971499	70
7989		3.9024924	71
20000000		7.3010300	72
(70 + 71 — 72)	.0012549	3.0986123	73
— (73)		2.9013877	74
(74) — 2 (70)	80.74	1.9070879	75
$43083.04 = t_3$		4.6342963	76
(44) + 3 (76) — 2 (70)		6.0579983	77
(55 — 77)	80.957	1.9082566	78
81.957		1.9135861	79
(44 + 76)		2.4180018	80
2 (80) + (78) — 2 (56) — (79)		T.9686987	81

460. *Series of Harmonic Equations.*

The harmonic analogy between the Neptune-Uranus and the Mars-Mercury belts may be still further extended by the following equations, which enable us to deduce all the masses of the primary planets from the harmonic value of the mass at the chief centre of condensation:

$$g = \frac{v_\lambda\, m}{t\, r^2} \qquad \alpha$$

$$\tfrac{1}{2} \times \tfrac{1}{2} \times \sqrt{g_3\, r_3} = \sqrt{\gamma_3\, \rho_3} \qquad \beta$$

$$t_\alpha \div t_\beta = m_8 \div m_3 \qquad \gamma$$

$$\pi^2 (1 + e_3)\,(m_8 + m_7) = m_5^3 \qquad \delta$$

$$\pi^2 (m_1 + m_4) = m_2 + m_3 \qquad \varepsilon$$

$$\rho_3' \div \rho_7 = m_3^3 \div m_7^3 \qquad \zeta$$

$$m_0\, m_3\, m_6 = m_5^3 \qquad \eta$$

$$\rho_1 \div \rho_4 = m_1^3 \div m_4^3 \qquad \theta$$

$$\rho_2 \div \rho_3 = m_2^2 \div m_3^2 \qquad \iota$$

461. *Explanation.*

In the foregoing note g = gravitating acceleration of any mass m, at any distance r, provided m and r are expressed in units of Sun's mass and semi-diameter; v_λ = velocity of light; t = time of solar half-rotation; γ_3 = solar gravitating acceleration at Earth's mean radius vector (ρ_3); t_β = time of theoretical satellite rotation at Earth's equatorial surface =

$2\pi\sqrt{\frac{r_3}{g_3}}$; t_a = a sidereal day; e_8 = Neptune's minimum secular eccentricity; ρ_8' = Neptune's mean secular aphelion; ρ_1 to ρ_8 = mean vector radii and m_1 to m_8 = masses of the eight primary planets.

The equations represent various obvious radial and tangential actions and reactions. Equation (1), when applied at the Sun's surface, which is the point of greatest gravitating acceleration in the solar system, gives $g\,t = v_\lambda$. This satisfies Ohm's law, as applied to solar rotation in a magnetic field, Fourier's theorem, Laplace's principle of periodicity, and the projectile velocity which balances æthereal resistance at Sun's surface. The actions and reactions of centripetal gravitation and centrifugal radiation are thus coördinated in such ways as to give simple forms of expression for all kinetic correlations. Equations (4) and (5) represent similar tangential tendencies to belt formation by the *vis viva* of primitive tangential motion, both at the outer limits of the solar system and at the outer limits of the belt of greatest condensation. Equation (2) represents a harmonic relation of tangential velocities, at the chief nucleal centre and at the chief centre of condensation. This equation satisfies Laplace's demonstration of the tendency to exactness in simple numerical relations. It also satisfies various tendencies of subsidence as well as of linear and of rotary inertia. Equation (9) gives harmonic tangential velocities to the two interior companion masses, in the belt of greatest condensation. Equations (6), (7) and (8) represent radial and belt-rupturing tendencies of simple subsidence. In the mutual interactions of gravitating subsidence the sums of the gravitating accelerations, along mutually connecting lines, vary as the respective masses; therefore $\frac{mg^2}{2}$, or the *vis viva* of subsidence, varies as m^2. Equation (3) represents harmonic interactions between the centre of primitive subsidence (m_8) and the chief centre of condensation (m_4). The importance of these interactions is still further exemplified by the fact that $(t_\beta \div t_a)^2$ = Earth's oblateness according to Listing's estimate (Note 440). This accordance seems calculated to throw great doubt upon Delaunay's hypothesis of retardation by the "tidal brake."

462. *Deduced Values.*

The following harmonic values satisfy the equations of Note 460. Some of the latest astronomic estimates are also given, in order to show the closeness of accordance:

	Harmonic.	Astronomical.	
$m_0 + m_1$	4527977	4512885	Encke.
$m_0 \div m_2$	387066	396256	Hill.
$m_0 \div m_3$	329196	329161	Faye.
$m_0 \div m_4$	2867780	2869157	Hall.
$m_0 \div m_5$	1049.4	1050	Leverrier.

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	Harmonic.	Astronomical.	
$m_0 \div m_6$	3510.7	3512	Leverrier.
$m_0 \div m_7$	22508.7	22600 ± 100	Newcomb.
$m_0 \div m_8$	19384.6	19380 ± 70	Newcomb.

463. *Evidence of Nebular Subsidence.*

The outer portion of the Neptune-Uranus belt is harmonically connected with the belt of greatest condensation, as we have seen (Note 440), by an important mass-relation. One linkage of the inner portion of the same belt was given in Note 442; another is found in the proportion

$$t_\alpha : t_\beta :: (\rho_3 + \tfrac{1}{2}\rho_0)^2 : \rho_7^2.$$
$$1 : 366.2565 :: (1.00233155)^2 : (19.18244)^2$$

Leverrier's estimate of ρ_7 is 19.18264, which differs from the harmonic estimate by less than $\frac{1}{4}$ of Sun's semi-diameter. This harmony introduces: (1) The rupturing tendencies of nebular subsidence through $\frac{1}{2}r$; (2) The interstellar parabolic influences which have determined the harmonic positions of the eight primary planets and of the asteroidal belt (Note 46); (3) The conversion of parabolic into elliptical influence, with foci at the centres of Earth and Sun; (4) The variation of the times of nebular rotation inversely as the square of radius. These relations, taken in connection with equation δ, Note 460, furnish conclusive evidence in support of Herschel's "subsidence theory."

464. *Earth's Dependence on Luminous Undulation.*

The influence of luminous undulation in determining Earth's orbital period is quite as remarkable as its influence upon the time of solar rotation. The latter represents the maximum energy, while terrestrial revolution represents the mean energy of luminous undulation, in accordance with the general principle that, when a disturbance consists of terms involving sines or cosines of angles which vary with the time, the maximum energy is twice the mean energy. According to Stockwell, the secular centre of the belt of greatest condensation is at $1.0169394_{\rho 3}$, which is an arithmetical mean between Earth's mean radius vector and its mean aphelion. Earth, like Jupiter, shows the energy of æthereal projection as well as the mean energy of luminous undulation. We find, accordingly, $g_3 \times 1 \text{ year} = 1.0338788 v_\lambda$. This gives $v_\lambda = 185501.5$ miles.

465. *Jupiter's Dependence on Luminous Undulation.*

The combined influence of luminous undulation and central condensation, in determining Jupiter's orbital velocity, is equally striking.

$$1.0169394 r_3 : \rho_3 :: \sqrt{\gamma_3 \rho_3} : v_\lambda.$$

Substituting the harmonic value of ρ_3 (92542800), this proportion gives $v_\lambda = 185498.1$ miles.

466. *Neptune's Dependence on Luminous Undulation.*

The varied harmonies which have been pointed out between the Neptune-Uranus belt and the dense belt, may naturally lead us to seek for some additional evidence of luminous influence at the outer limit of the solar system. Such evidence is furnished by the proportion:

$$\rho_\alpha : \rho_\beta :: \rho_\gamma : \rho_s.$$

In this proportion ρ_α = Neptune's secular aphelion + Earth's mean aphelion; ρ_β = Neptune's secular aphelion; ρ_γ = centre of belt of greatest condensation. Substituting Stockwell's apsidal elements and the harmonic value of ρ_s, the proportion gives $v_\lambda = 185492$ miles. The extreme range of discrepancy in the three estimates (Notes 464–6) is less than $\frac{1}{1\,3\,5\,1}$ of one per cent, or less than ten miles per second.

467. *Harmonic Estimate of the Constant of Aberration.*

Earth's mean orbital velocity is $1296000'' \div 31558149 = 0''.041067$; $v_\lambda = 185497.2$ miles, if we take the mean of the three foregoing estimates. To find the constant of aberration we have the proportion:

$$185497.2 : 92542800 :: 1 \text{ sec.} : 498.89 \text{ sec.}$$
$$0''.041067 \times 498.89 = 20''.488.$$

The close accordance of this value with Nyrén's estimate (Note 449), furnishes satisfactory confirmation both of the accuracy of Stockwell's calculations and of the precision of the harmonic estimate.

468. "*V.*"

The foregoing results abundantly show that the principle of harmonic motion is of "immense use not only in ordinary kinetics, but in the theories of sound, light, heat, etc." * Analogy, the law of parsimony, the theories of kinetic correlation, and the various principles enumerated in Note 461, all point to the value of v_λ, which is given in the foregoing note, as equivalent to the ratio "*V*" between the electrostatic and electromagnetic units of electricity, electric current, magnetic potential, electric displacement, surface density, magnetic force, and strength of current at a point. The corresponding resistance in the field of rotation is 29.853 Ohm's. This agrees very closely with Foucault's estimate, 29.836 Ohm's. Weber's estimate † was 31.074; Thomson's ‡ 28.2; Maxwell's ‡ 28.8; Michelson's § 29.982. The modulus of light which is represented by the harmonic constant of aberration may be found as follows: $r_0 = \rho_3 \div 214.4513 = 431532.8$ miles; $g_0 = m_0 r_3^2 \div m_3 r_0^2 = .16878$ miles; $\pi r_0 \div v_\lambda = 7.3085$ sec.; $7.3085 g_0 = 1.233$ miles $= v$ of solar rotation; $\sqrt{g_0 r_0} = 269.82$ miles; $269.82 \div 1.233 = 218.833$; $(218.833\pi)^2 r_0 = 472633 r_0 =$ modu-

* Thomson and Tait, *Nat. Phil.*, 1, Sec. 52.
† *Pogg. Ann.*, Aug. 10, 1856.
‡ Rept. Brit. Assoc., 1869, pp. 434, 436.
§ *Am. J. Sci.*, Nov., 1879.

lus of light at Sun's surface; Laplace's limit, $L = 218.833^{\frac{2}{3}} r_0 = 36.314 r_0$. An additional linkage of Sun, Earth, Jupiter and Neptune is shown by the proportion:

$$L : \rho_3 :: \rho_{3.2} : \rho_{3.3}.$$

In this proportion $\rho_{3.2}$, $\rho_{3.3}$ represent secular perihelion of Earth and Neptune, respectively. Substituting Stockwell's value of $\rho_{3.3}$ gives $\rho_{3.2} = 29.68\rho_3$. Stockwell's estimate is $29.73\rho_3$.

469. *Another Linkage of Jupiter and Earth.*

Let v_a = *vis viva* of circular orbital revolution which Jupiter, when at mean aphelion, would be able to give to a particle at the centre of the solar system $= m_5^2 \div \rho_a$; v_3 = molecular *vis viva* which Earth would be able to communicate to the same particle $= \frac{2}{5}(m_3^2 \div \rho_3)$; v_λ = velocity of light; v_3 = circular orbital velocity of a particle at the chief centre of condensation in the solar system (Earth). Then we find $v_a : v_3 :: v_\lambda : v_3$. Substituting the harmonic values of Earth's mass and of the constant of aberration, with Stockwell's estimate $\rho_a \div \rho_3 = 5.427351$, we find $v_\lambda \div v_3 = 10067.61$; $m_5 \div m_3 = 313.61$; $m_0 \div m_5 = 1049.69$, which differs by less than $\frac{1}{3\frac{1}{7}}$ of one per cent from the value which was deduced in Note 462. This relation shows that, when nebular subsidence and luminous undulation had established incipient orbital motion around the Sun at Jupiter's mean aphelion, the actions and reactions among nucleal centres established the molecular motion, at the chief centre of density, which resulted in Earth's orbital oscillation. The first indication of the importance of the factor $\frac{2}{5}$ appears to have been given by me (Proc. Amer. Phil. Soc. xii, 394). Maxwell subsequently adopted it (P. Mag., June and Sept., 1877, pp. 453, 209) without leaving any record of the source from which he derived it, or of the reasons upon which it was based In all of my investigations my first inquiry is, what obvious radial or tangential velocity, momentum, or *vis viva* is there, which would be likely to operate in producing or maintaining such exactness of cyclical harmony as is necessary for the stability of the system. The first trial usually gives some clue which suggests the next. These alternations, between Baconian observation and the "scientific use of the imagination," have been rewarded by frequent confirmations of predictions which I had hazarded and recorded weeks, months, or years, before they could be sustained by any known data.

470. *Dense-Belt Projection.*

The interstellar parabolic trajectories, which have tangential directices at Sun's surface, and a common focus at Sun's centre, have a vertical locus at $\frac{r_0}{2}$. The length of the luminous undulation which becomes semi-circular in solar rotation is πr_0. The sum of these two centrifugal

tendencies is $3.641593r_0$, or $.0169414\left(\rho_3+\frac{\rho_9}{2}\right)$, which differs by less than $\frac{1}{24}$ of one per cent from Stockwell's estimate of the projection of the centre of the dense belt. For the influence of $\rho_3+\frac{\rho_9}{2}$ upon the orbital locus of Uranus, see Note 463.

471. *Sun's Equatorial Acceleration.*

The luminous projection of Jupiter and of the centre of the dense belt, as well as the other evidences of apsidal influence upon planetary harmonies, show that molecular *vis viva* has slightly modified the simple undulatory *vis viva* of the luminiferous æther. The amount of the solar equatorial acceleration is not precisely known, because no Sun-spots have been observed very near the solar equator; it cannot, however, differ much from Earth's mean secular eccentricity. We may, therefore, regard this as another evidence of the harmonic importance of "subsidence" to the belt of greatest density.

Stated Meeting, June 20, 1884.

Present, 5 members.

President, Mr. FRALEY, in the Chair.

A letter accepting membership was read from James H. Hutchinson, M.D., dated May 16, 1884, No. 133 South Twenty-second street, Philadelphia.

The decease of Prof. Dr. Heinrich Robert Göppert, at Breslau, May 18, 1884, aged 83, was announced.

A letter was received from J. M. Da Costa, M.D., accepting the appointment to prepare an obituary notice of the late Dr. Gross.

Prof. Baird requested, by letter, a copy of Proceedings No. 110 for the Library of the Imperial Museum at Strasburg, which was ordered to be sent.

Prof. E. D. Cope requested, by letter, the insertion of a paragraph in the Proceedings enlarging the notice of the minutes of January 18, 1884.

An application was read for the Magellanic Premium, signed "*Arcturus*," on the explosion of tanks containing petroleum, and the method of preventing the same.

Prof. Cope sent a paper on the Extinct Mammalia of Valley of Mexico.

Mr. Richard Vaux read a paper on the history of the Pennsylvania prison system.

Nominations Nos. 1023 to 1028, were read.

Letters of acknowledgment were received from the Holland Society at Harlem (114); the Fondation Tyler (114); the Royal Zoölogical Society, Amsterdam (113, XVI, i); the Observatory at Prague (113, XVI, i); the Royal Society of Sciences, Göttingen (XIII, i, ii); the Radcliffe Observatory (114); the Royal Observatory, Edinburgh (113, XVI, i); Wm. Blades, 23 Abchurch Lane, London (114); the Statistical Society, London (114).

Letters of Envoy were read from the United States Consul at Budapest, April 29, 1884; the Royal Zoölogical Society, Amsterdam, June 4; the Musée Guimet, April 16, and the National Academy at Cordova, South America, requesting exchanges.

Donations for the Library were received from the Geological Survey of India; Academy at St. Petersburg; Mr. Joseph de Lenhossek, of Budapest; Anthropological Society, Geological Institute, Vienna; Royal Bavarian Academy; Royal Saxon Society; Royal Society, Göttingen; Royal Prussian Academy; Society at St. Gall; National Antiquarian Society, Copenhagen; Tuscan Society of Natural Sciences, at Pisa; Musée Guimet and Society Agriculture, Lyons; Commercial Geographical Society and Meteorological Commission, Bordeaux; Institute of France, Ethnological Society, Anthropological Society, Zoölogical Society, Geographical Society, M. Leon de Rosney, Society of Americanists, Society for Japanese Studies, Bureau of Longitudes, M. M. Locroy, Paris; Royal Academy of History at Madrid; Astronomical Society, Geographical Society, Nature, London; Cambridge University; Glasgow Observatory; Pat-

rick Geddes, of Edinburgh; Nova Scotia Institute of Sciences; Boston Society Natural History; American Journal Science; American Chemical Society; New York Historical Society, New York Academy of Sciences, New York Meteorological Observatory, Philadelphia Academy Natural Sciences, Franklin Institute, Journal of Pharmacy, Engineers' Club, Zoölogical Society, Dr. Geo. L. Harrison, J. A. Kirkpatrick, Heber S. Thompson, Edwin Atlee Barber, Henry Phillips, Jr., E. D. Cope, A. E. Foote, Eli K. Price, American Journal of Philology, Baltimore Johns Hopkins University, United States National Museum, United States Army Bureau of Engineers, Census Bureau, Jed. Hotchkiss, of Staunton, Virginia, American Antiquarian, Chicago.

And the meeting was adjourned.

Stated Meeting, July 18, 1884.

Present, 3 members.

President, Mr. FRALEY, in the Chair.

A letter was received from the President of the Committee for erecting a statue to Jean Baptiste Dumas, and requesting a subscription for the same.

The death of Dr. Karl Richard Lepsius was announced as having taken place July 11, 1884, ætat. 83.

A letter was received from Gen. W. F. Reynolds announcing a change of address to Detroit, Michigan.

Letters of acknowledgment were received from the Royal Academy of Sciences, Amsterdam (113, XVI, i); Royal Institute, Lombardy; Prof. J. S. Steenstrup (113); K. K. Central Institute (114); University Library, Cambridge (114); New Hampshire Historical Society, Concord (115); American Antiquarian Society, Worcester (115); Essex Institute (115); Boston Athenæum (115); American Statistical Asso-

ciation, Boston (115); Connecticut Historical Society (115); W. P. Blake, New Haven (115); W. D. Whitney, New Haven (115); New York Historical Society (115); Library United States Military Academy, West Point (115); C. H. F. Peters, Clinton, New York (115); New Jersey Historical Society (115); Numismatic and Antiquarian Society (115); Wyoming Historical and Geological Society, Wilkes-Barre (115); Pennsylvania State Library (115); Thos. C. Porter, Easton, Pennsylvania (115); Leander McCormick Observatory, Virginia (115); Georgia Historical Society (115); Cincinnati Observatory (115); Robert Peter, Lexington (115); Library of the University of Tennessee (115); Henry S. Frieze, Ann Arbor (114, 115); State Historical Society of Wisconsin (115); Kansas State Historical Society (115); Geological Survey, Washington, a set of the publications of the American Philosophical Society.

Letters of envoy were received from the Society of Natural Sciences of Elberfeld, and the Royal Society of Canada.

Donations to the Library were received from the New Zealand Institute; Royal Friedlander, Berlin; K. K. Observatory in Prag; Societies of Natural Sciences at Emden, Elberfeld and Lausanne; Central Bureau of Statistics, Stockholm; Royal Academy of Belgium; Royal Observatory at Bruxelles; M. Paul Albrecht; Ecole des Mines; Societies of Geography at Paris and Bordeaux; M. B. Balliere & Son; M. Paul Tournafond; Society of Physical and Natural Sciences at Bordeaux; Prof. C. H. F. Peters; Prof. Luigi Ambiveri; Society of Antiquaries; Royal Astronomical Society; Journal of Forestry; Nature; Essex Institute; M. Franklin B. Hough; American Academy of Arts and Sciences; American Oriental Society; the Boston Society of Natural History; S. E. Cassino & Co.; the Peabody Museum; Harvard University; the Free Public Library of New Bedford; American Journal of Science; Yale College; American Chemical Society; Mercantile Library; New York Meteorological Observatory; American Journal of Medical Sciences; College of Pharmacy; McCalla & Stavely; the Franklin Institute; Prof.

E. D. Cope; Dr. D. Jayne; Mr. Henry Phillips, Jr.; the Wyoming Historical and Geological Society; Johns Hopkins University; Peabody Institute; United States Geographical and Geological Survey; Department of the Interior; Mr. Jed. Hotchkiss; Geological Survey of Kentucky, and the National Academy of Sciences in Cordova (Argentine Republic).

Permission was granted to Mr. Henry Phillips, Jr., to have copies made of Schultze's Arawak grammar and dictionary (MSS. owned by the Society), for the use of Mr. E. F. im Thurn, of Demerara, British Guiana.

The Special Committee, appointed May 16 to have the paintings owned by the Society cleaned and put in good order, was ordered to ascertain the cost of photographing the same.

The following new members were elected:

Sir John Lubbock, LL.D., Westminster, London.
E. Burnett Tylor, LL.D., Museum House, Oxford.
Wm. W. Keen, M.D., Philadelphia.
N. Archer Randolph, M.D., Philadelphia.
Rev. E. W. Syle, D.D., Philadelphia.
Rev. H. Clay Trumbull, D.D., Philadelphia.

New nominations, Nos. 1029, 1030, were read, and the meeting was adjourned.

Correction of Minutes of January 18.

Professor Cope remarked that the formation which forms the banks of the Rio Grande at Laredo, Texas, is in all probability the Laramie. It contains at that point a thick bed of pure lignite. Above Laredo, on both sides of the river, an excellent lignite is mined. The wide valley of the Rio Grande as far as the eastern ranges of the Sierra Madre is probably of Laramie age, as Dr. C. A. White reports fossil mollusca of that age from near Lampazas, at the foot of the mountains. Wm. Arthur Schott (U. S. Mex. Bound. Survey I, Geology, p. 35) first observed these lignites, and Mr. Conrad pointed out the existence of Claiborne Eocene beds in the same region (loc. cit., p. 141). Professor Cope stated that the Claiborne beds rested immediately on the Laramie at Laredo.

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Notes upon the Codex Ramirez, with a translation of the same. By Henry Phillips, Jr.

(*Read before the American Philosophical Society, October 19, 1883.*)

Perhaps one of the most valuable fragments of antiquity that has survived the bigoted fury of the Spanish ecclesiastics is the Codex Ramirez, a history of the Mexicans as shown forth by their hieroglyphical and symbolical writings. It was prepared shortly after the Conquest by the orders and for the use of Señor Ramirez de Fuen Leal, Bishop of Cuenca, President of the Chancelleria, to be used in deciding upon questions of all nature that were likely to arise before that tribunal. He caused the Aztec sages and priests to come together before him, and to agree upon an explanation of the characters and signs in which the law, history and mythology of the Mexicans were written. As an authentic exposition of such, it is unique and of the greatest value to students.

Brinton (Am. Hero Myths, 78), calls it "the most valuable authority we possess;" Pinelo (Vol. II, 603), refers to its having been used by Herrera; Chavero (Anales del Museo Nacional, III, iv, 120), "*se considera como la mejor fuente, acaso la unica verdaderamente autorizada, para conocer los hechos pasados en Tenochtitlan.*" When Bishop Ramirez returned to Spain, he took with him this MS., which now exists in Madrid in a volume of twelve leaves folio entitled *Libro de oro y Thesoros Indicos*, and bears upon it various memoranda attesting its authenticity.

The work is extremely difficult to understand, and full of obscurities arising partly from errors in transcription, partly from the use of antiquated expressions, and a most involved and puerile style, and partly from incorrect and vulgar orthographies.

In the following translation I have endeavored to reproduce the simplicity and meaning of the original, adding copious notes of explanation and conjecture wherever a passage seemed to demand it.

(NOTE.—*Tz* is pronounced like the Maya *Ç*; *X* like the sound of *sh* in English; *t* between two "l"s is dropped; *o* and *u* were pronounced almost identical (*Molina*). Anales de Museo Nacional, I, VI, 242.)

HISTORY OF THE MEXICANS AS TOLD BY THEIR PAINTINGS.

CHAPTER 1ST.

Of the Creation and Beginning of the World and of the Original and Superior Deities.

Through symbols and writings formerly used, through the traditions of the old and of those who in the days of their infidelity were priests and pontiffs, and through the narrations of the lords and chief men to whom they were accustomed to teach the law and educate in their temples in order to render them learned, brought together before me with their books and hieroglyphics, which according to what is demonstrated are believed

Codex Ramirez, Proc. Amer. Philos. Soc., Vol. XXI p. 616.

This Map of the Environs of the City of Mexico is reproduced from *Le Petit Atlas Maritime* * * * (par Le Sieur Bellais, par ordre de M. Le Duc de Choiseul. Paris, 1764). Vol. 2, Pl. 5. The configuration of the Lakes of Mexico and Chalco, however, is incorrectly represented.

to be of ancient origin, many of them anointed with human blood, it appears that there was originally one god named *Tonacatecli*,[1] who took for wife *Tonacaçiguatl*, or as she is sometimes called *Cachequacalt*, who created themselves, and were perpetual inhabitants of the thirteenth heaven; of whose creation and beginning likewise there is nothing known except the fact that it also originated in the thirteenth heaven. Of this god and goddess were engendered four sons, the eldest was called *Tlaclau queteztzatlipuca*,[2] whom the peoples of Quaxoçingo and Tascala reverenced as their chief divinity under the name of *Camaxtle*,[3] and who was said to have been born of a ruddy color all over. They had a second son named *Yayanque tezcatlipuca;* he who was the greatest and the worst, who overpowered and bore sway over the other three, because he was born in the middle of all (*naçio en medio de todos*); he was totally black at birth. The third was called *Queçalcoatl*,[4] and for another name *Yaguelicatl*. To the fourth and the smallest they gave the appellation of *Omitecilt*,[5] and *Maquezcoatl*, whom the Mexicans termed *Vchilobi*, because he was left-handed, and looked upon him as their chief deity, because in the land from whence they came, he was so considered, and was more especially the god of warfare than were the other divinities. Of these four sons of *Tonacatecli* and *Tonacaçigulatl* (*sic*), *Tezcatlipuca* was the one who knew all thoughts, and was in all places and read all hearts, for which he was called *Moyocoya*,[6] which is to say "the all-powerful," according to which idea he is represented in painting only as the air, by which name he is not commonly known. *Vchilobi*,[7] the younger brother, and god of the Mexicans, was born without flesh (*nacio sin carne*), but only bones, in which condition he lived six hundred years, during which period of time the gods did nothing whatever, the father as well as the sons, and in their representation there is no account taken of these six hundred years, counting them as they do from twenty to twenty, according to the sign which he holds, which stands for twenty. These gods were known by these and many other names, according to how their attributes are understood, for each community called them differently by reason of their dialects, and so they were given diverse appellations.

Chapter 2d.

Of how the World was created and by whom.

When the six hundred years after the birth of the four brethren-gods, the sons of *Tonacatecli*, had passed away, they all four came together, and said that it was good that they should arrange what they had to do, and the law they were to be governed by, and they all committed to *Quezalcoatl* and *Vchilobi*, the performance of this task, in pursuance of which they created, under the orders and judgment of the others, the fire, and this being done they made the half-sun, which, on account of not being entire, gave not much but only a slender light. Presently they created a man and a woman; the man they called *Vxumuco*, and the woman *Çipastonal*,[8] and to them they gave command that they should till the ground, and that the woman

should spin and weave, and that of them should be born the *Maçeguales*, and that they should find no pleasure, but should always be obliged to work; to the woman the gods gave certain grains of *maiz*,[9] so that with them she should work cures, and should use divination and witchcraft, and so it is the custom of women to do to this very day. Then they created the days which they divided into months, giving to each month twenty days, of which they had eighteen, and three hundred and sixty days in the year, of which will be spoken subsequently. Then they created *Mitlitlatteclet* and *Michitecaçiglat*, husband and wife, and these were the gods of the lower regions (*infierno*), in which they were placed; then the gods created the heavens below the thirteenth, and then they made the water and created in it a great fish similar to an alligator which they named *Çipaqli*, and from this fish they made the earth as shall be told; and to create the god and goddess of water, all the four divinities joined themselves together, and made *Tlalocatecli*,[10] and his wife *Chalchiutlique*,[11] whom they assigned to be the gods of water, to whom they betook themselves in prayer whenever it was needful. Of this god of water it was said that he had his dwelling of four apartments, in the middle of which was a large courtyard, where stood four large earthen pans full of water. In one of these pans the water was excellent, and from it the rain fell which nourished all manner of corn and seeds and grain, and which ripened things in good season; from the second rained bad water from which fell cobwebs on the crops, and blight and mildew ensued; from another fell ice and sleet; when from the fourth rain fell nothing matured or dried. This god of rain water created many servants, small of body, who were in the rooms of the aforesaid house, and they held money boxes,[12] in which they caught the water from the great earthen pans, and various rods in the other hand; and when the god of water sent them to irrigate any especial places, they started off with their boxes and sticks, and let fall the water where they were directed, and when it thunders the noise is caused by their striking the boxes with their rods, and when it lightens it comes from within these boxes. It is eighty years since Señor de Chalco wished to sacrifice to these servants of the gods of water one of his hunchbacks [13] and took him to the Volcano, a very high mountain always covered with snow, fifteen leagues distant from the City of Mexico, and placed the humpback inside of a cave of which the entrance was closed up, and from lack of food he became drowsy, and was carried to where he could see the aforesaid palace and the manner of life of the deity; sometime later the servants of Señor de Chalco came to look for him to see if he were dead, but finding him living, took him home where he told what he had seen; in this very year the people of Chalco were subdued by the Mexicans, and became enslaved, and it was said that this had been the signal for their loss as it took place. Afterwards all the four gods, being united in work, they created from the fish *Cipacuatli*[14] the earth, which they called *Tlaltecli*,[15] and represent as the god of the earth, extended over a fish as having been made of it.

Chapter 3d.

Of the Creation of the Sun, and how many Suns there have been, and how long each one lasted, and how the Maceguales ate in the time of each Sun, and of the Giants in those Days.

All the aforesaid was made, and created without any account being taken of the year, except that it was all in one, and without any difference of time, and it is narrated that of the first man and woman who did as has been already said, about the time when these things began to be performed, there was born a son to whom was given the name of *Pilcetecli*, and as there was lacking some woman for him to marry, the gods made of the hairs of *Suchiqueçar*,[16] a woman with whom his first marriage took place. When this was done all the four deities took notice that the half sun which they had created gave but very little light, so they resolved to make another half sun, so that it should illumine the whole earth. When *Tezcatlipuca* saw this he became himself a sun in order to give light, as we represent him in painting, and they say that what we see is only the brightness of the sun and not the sun himself, because the sun rises in the morning, traverses till midday, and then returns to the east in order to start again next day, and that which is visible from noon till sunset is its brightness, and not the sun itself, and that at night it neither shows itself nor has motion. So from being a god *Tezcatlipuca* made himself a sun, and then all the other deities created giants, who were very large men, and of such extreme strength that they could tear up trees with their hands, and they lived on the acorns of evergreen oak trees, and nothing else.[17] This state of affairs lasted as long as this sun did, which was thirteen times fifty-two years, which make 676 years.

Chapter 4th.

Of the manner which they have of reckoning.[18]

And since they commence to count time from this first sun, and their reckoning runs on from it continuously, leaving behind the 600 years, the period of the birth of the gods, and while *Vchilobus* was in his bones, and without flesh, as has been narrated, I shall now proceed to tell the manner and order in which they reckon their year, and this is it. As has been already said, each year contains 360 days, and 18 months, each month of 20 days; and of how they use up 5 days in festivals, which became fixed, we shall speak later in our chapters touching on the feasts and their celebrations. Holding the year as has been said they correct from four to four, and neither in their language nor in their paintings, take any account of more than four years. The first they call *tectapatl*, and paint it as a stone or flint with which they cut open the body in order to draw out the heart; the second, *cali*, which they represent as a house, for by this name they call a house; the third, *tochili*, whom they paint with a rabbit's

head, for by this term they name a rabbit; the fourth, *acal*, which they represent as a sign for water. They reckon with these four numbers and objects till they come to the thirteenth year, which then rounds the great cycle, like the indiction or lustrum of the Romans; and when finished four times thirteen, the four years being run four times thirteen, making fifty and two, this they call an age (epoch), and when fifty and two years are ended, with much pomp they celebrate *the great year*, and place the period with those already passed, and re-commence anew their four year computation; the festival of which and the entrance into the new cycle was celebrated among the Mexicans by extinguishing all the lights that existed, and the priests would go to seek light again at a temple situated on a high mountain near *Estapalapa*, where the ceremonies took place, about two leagues distant from Mexico. They then continued henceforth their count of four years, and then of thirteen, till they had reached their fifty-two, and so on from fifty-two to fifty-two for all time.

Returning to the giants who were created at the time when *Tezcatlipuca* was the sun, it is said that when he ceased to be the sun, they all perished, and tigers made an end to them and ate them up, so that no one remained; and these tigers were created in this fashion; that after thirteen times fifty-two years had passed *Queçalcoatl* became the sun, and *Tezcatlipuca* ceased to be it, because he gave him a blow with a great stick, and threw him over into the water, and there he was metamorphosed into a tiger, and issued forth thence to slay the giants; and this appeared in the heavens, for it is said that the *ursa major* came down to the water because he is *Tezcatlipuca*, and was on high in memory of him.

In these eras the Maceguales ate the nuts of the pine trees and nothing else, which lasted while *Queçalcoatl* was the sun, during thirteen times fifty-two years, which was 676 years, which being come to an end *Tezcatlipuca*, on account of being a god did the same actions as his other brothers, and hence was made a tiger, and gave a kick in the breech to *Queçalcoatl*, which upset him and finished his term of being the sun; and then a terrible wind arose which carried away all the Maceguales, except a few who remained suspended in the air, and the rest turned into apes and monkeys; then *Tlalocatecli*, the god of the lower regions, became the sun, and remained so seven times fifty-two years, which are 364 years, in which time the Maceguales had nothing to eat, but *açiçiutli*, which is a species of seed of a grain which is born in the water. When these years were over, *Queçalcoatl* sent down a rain of fire from heaven, and deprived *Atlalocatecli* of being the sun, and made his wife *Chalchiutlique*, the sun in his place, who remained so six times fifty-two years, which are 312 years, and during that time the Maceguales ate only a seed of a grain like maize named *cintrococopi*.[19] And so from the birth of the gods to the fulfillment of the sun according to the count were 2000 and 600 and 20 and 8 years.

Chapter 5th.

Of the Deluge, and of the Fall from Heaven and of the Restoration.

In the last year of the sun *Chalchiutlique*, as has been told, it rained so much water and so great an abundance thereof that the heavens themselves fell, and the waters carried away all the Maceguales that were, and from them were made all manner of the fishes that exist at the present day; and so there ceased to be any more Maceguales, and the heaven itself had ceased to exist, for it had fallen upon the earth.[20] And when the four gods had seen that the heaven had fallen on the earth, which took place in the first year of the four after the sun had ended, and the rain had fallen, which was the year *tochili*, they ordained that all the four should make through the centre of the earth four roads by which to enter it in order to raise the heaven, to assist in which task they created four men; one they called *Cotemuc*, another *Yzcoaclt*, another, *Yzmali*, and the fourth *Tenesuchi*. These four men having been created, the two gods, *Tezcatlipuca* and *Quiçalcoatl*, then formed themselves into enormous trees,[21] *Tezcatlipuca* becoming the one known as *Tazcaquavilt*, meaning the tree of the mirror, and *Quiçalcoatl*, the *Queçalhuesuch*, and gods and men and trees together raised on high the heaven and the stars, just as they are to-day, and as a recompense for having raised them, *Tonacatecli*, the father, made them lords of the heaven and the stars; and when the heaven was raised, *Tezcatlipuca* and *Quiçalcoatl* walked through it, and made the road which we now see there, and met in it, and remained there in it, and held their abode there.

Chapter 6th.

What happened after the Raising of the Heaven and Stars.

After that the heaven was lifted up, the gods renewed life to the earth which had expired when the heaven fell upon it, and in the second year after the deluge which was *acalt*, *Tezcatlipuca* altered his name, and changed himself into *Mixcoatl*,[22] which means viper of snow, and for this reason he is painted among the gods a viper. In this year he desired to feast the gods, and for this purpose drew a light from the rods whence they were in the habit of drawing it, and hence the origin of drawing fire from flint, which are rods that have a heart. The fire being once drawn, it was the festival of making many and large flames.

From this second year in which fire came forth until the sixth, nothing happened noteworthy, except that in the sixth year after the deluge *Çinteul* was born, son of *Picenticli*, eldest son of the first man, who, because he was a god and his wife a goddess, being made of the hairs of the goddess mother, could not die; two years later, which was the eighth year after the deluge, the gods created the *Maceguales*, just as they had formerly existed, and there is no record of any other event till this cycle of thirteen years was accomplished. In the first year of the second cycle of thirteen years thereafter all the four gods came together and said that the earth had no light

but was in darkness, there being nothing else to give any light save the fires, so they created a sun to illuminate the earth, and this sun should eat hearts and drink blood; so to feed it they were obliged to carry on continual warfare to obtain for it blood and hearts. And since it was the will of all the gods that it should be so, in the first year of the second cycle of thirteen, which was the fourteenth after the deluge, they made a war which lasted two years till it was finished; again in three years they made war, in which time *Tezcatlipuca* created 400 men and five women, so as to have some people for the sun to eat,[23] these men lived only four years after which the women were the sole survivors. In the decennial year of this second thirteenth it is said that *Suchiçicar*, first wife of *Piçiçiutecli*, son of the first man, died in the war, being the first woman to expire in warfare, and much the next powerful of all women, so many as died in war.

Chapter 7th.

How the Sun was made and what took place afterwards.

In the thirteenth year of this second cycle of thirteen, which is in the twenty-sixth year after the deluge, we have seen how the gods agreed to make the sun, and how they made war in order to give it something to eat, *Quiçalcoatl* wanted to make his son the sun, of whom he was the father but who had no mother, and at the same time *talocatecli*, the god of water, made to himself a son by *Chalchiutli*,* his wife, which is the moon, eating nothing until (*here there is a lacuna in the original*), and they drew blood from their ears,[24] and with this they fasted, and they drew blood from their ears, and their body in their prayers and sacrifices; and this being done *Quiçalcoatl* took his son and heated him red hot in a great fire, from whence he issued as a sun to illumine the earth; and after the fire died out, *Talocatecli*,[25] came and threw his own son in the cinders from whence he issued forth as the moon, for which reason he appears ashy colored and obscure. In the last year of this thirteen, the sun began to give his light, for before that time it had always been night, and the moon began to run after the sun, and never to catch up with him, and they traversed the air perpetually without ever arriving at the heavens.

Chapter 8th.

Of what happened after the Sun and Moon were made.

One year after the sun was made, which was the first of the third thirteen after the deluge, Camasale, one of the four gods, went to the eighth heaven, and created four men and one woman for a daughter, so that they should go to war, that there should be hearts for the sun and blood for it to drink; and being made they fell into the water, and then returned to heaven, and as they fell and there ensued no war, the next year, which was the second of the third thirteen, the same *Camasale*, or as he is sometimes called *Mixcoatl*, took a rod and struck with it on a rock from which sallied forth forty *Chi-*

*See Note 12.

chimecas,[26] and this they say was the beginning of the *Chichimecas*, which we call *Otomis*, which in the language of Spain signifies mountaineers, and these, as we shall narrate hereafter, were the inhabitants of this country before the Mexicans came to conquer, and to dwell there; and in the eleven years following of this third thirteen, Camasale[27] did penance, taking the thorns of the maguëy and drawing blood from his tongue and ears, and for this reason it is the custom to draw blood from such places with the thorns whenever they supplicate the gods. He did this penance so that his four sons and daughter that he had created in the eighth heaven should descend and slay the *Chichimecas*, so that the sun should have hearts to eat; and in the eleventh year of the third thirteenth, down came the four sons and the daughter, and placed themselves in some trees whence they fed eagles; and now it was that the *Camasale* invented the wine of the maguëy and other kinds of wines in which the *Chichimecas* busied themselves, and knew nothing better than drunkenness; and being in the trees the sons of *Camasale*, they were seen by the *Chichimecas*, who went to them, so they descended from the trees, and slew all the *Chichimecas*, only three escaping; one was called *Ximbel*, another *Mimichil*, and the third was the *Camasale*, the god who had created them, and who transformed himself into a *Chichimeca*. In the eighth year of the fourth thirteen after the deluge there was a great noise in the heaven from whence there fell a deer with two heads, and *Camasale* caused it to be caught, and ordered the men who then inhabited *Cuitlalavacu*, three leagues distant from Mexico, that they should capture that deer and regard it as a god, and they did so, and they gave it for four years to eat of rabbits and vipers and butterflies; and in the eighth year of the fourth thirteen *Camasale* had a war with some of his adjoining neighbors, and in order to conquer them he took the aforesaid stag and carrying it to them overcame them; and in the second year of the fifth thirteen did this same god *Camasale* celebrate a festival in heaven, making many fires; and until there was completed the fifth thirteen after the deluge did *Camasale* keep on continuously making war, and with it he gave nutriment to the sun.

They say, and the paintings likewise show it, that in the first year of the sixth thirteen the *Chichimecas* waged war against *Camasale*, and took away his deer, through which he was enabled to be victorious; and the reason why he lost it was that while wandering about the field he fell in with a female relation of *Tezcatlipuca*, a descendant of the five women whom he had made at the time when he created the 400 men which latter died, but the females remained alive, and this one was descended from them, and bore a son who was known as *Ceacalt*,[28] and in this thirteen they represent that afterwards when *Çeacalt* (*sic*) was a youth he did seven years of penance, wandering alone through the mountains, and drawing blood from himself that the gods might make him a mighty warrior. And in the sixth thirteen after the deluge began, this *Çeacalt* to wage war, and he was the first lord of *Tula* whose inhabitants chose him for their chief on ac-

count of his valor. This *Çeacalt* lived until the second year of the ninth thirteen, being lord of *Tula*, and four years before that time he built a very large temple in *Tula*, and when he had done it there came to him *Tezcatlipuca*, who told him, that towards *Honduras*, in a place which is now called *Tlapalla*, there was a house built for him, and that there he should betake himself and breathe his last, for that he must go away from *Tula*,[29] in which town *Çeacalt* was reverenced as a god; to what *Tezcatlipuca* said to him, he replied that the heavens and the stars had told him that it was his fate to leave there within four years And so when these four years were completed, he departed and took with him all the *Maceguales* of *Tula*, and left them at the city of *Chulula*, whence are descended all its inhabitants, and others he left in the province of *Cuzcatan*, whence descends the present population of that place, and in the very same manner he left behind him in *Çempoal* others who settled there, and he proceeded on his journey till he reached *Tlapala* (*sic*), and on the very day in which he arrived there he fell ill, and on the day following he died. Then *Tula* remained depopulated, and without a lord nine years.

Chapter 9th.

Of the beginning and coming of the Mexicans to this New Spain.

It is said that after the completion of ten thirteens after the deluge, which are 130 years, the Mexicans were settled in a community named *Azcla* to the west of the New Spain slightly trending toward the North, which was very much populated, and in whose centre stood a mountain whence issued a fountain which became a river, like *Chapultepeque*[30] is in Mexico, and on the other side of this river was another settlement, and a very large one, named *Culuacan*,[31] and since their computation begins with the first year of their emigration, so from now on for the future we shall reckon time starting from the year in which this Mexican agreed to sally out to find new lands that they might conquer, and for that reason they chose three war chiefs or captains, one they named *Xinçi*, another *Tecpaçi*, and the third *Coantlique*, and with these three started off many Mexicans (the paintings do not set out their number), and they carried with them the figure and manner of constructing their temples, so as to be able to erect them to *Vchilobi* wherever he should come. So they took their adieu of the temple they had in *Azcla*,[32] and began their journey, for which reason the painting representing their expedition, makes its beginning with the temple.

Chapter 10th.

How they Departed, the People of Culuacan, and what Peoples went with them, and how they were named.

As has been already narrated on the eastern side of the river they represent the City of *Culuacan*, a very large city with many populous places around it filled with people, on the account of which the inhabitants determined

to seek a country to settle in, and being united they took for captain and war-chief one named *Ynqualtlatlanqui*, and they took the names of the old towns and places they had left, and gave them to new ones in the country to which they immigrated. It is said that the following people went with them, and each one took its own god which it worshiped, and the manner of its own temple, for in each one the service was different, and no one was identical with another, for which reason they are painted dissimilar; and so there went forth with them those of *Culuacan*, which was the principal city, and was placed in the new settlement distant two leagues from the one whence they populated it as they came, of which more will be said in the hereafter. They took their gods, named *Çinteul*, son of *Pinçetecli*, *Suchimulco*[33] went with them, taking his god named *Quelazcli*, who was the stag of *Mixcoatl*[34] as has been told; *Atitlalabaca*, went forth with his god *Amimicli*, which was a rod of *Mixcoatl* whom they reverenced as a god, and carried that rod in memory of him; *Mizquique*, went forth with *Quiçalcoatl* as his god; *Chalco*[35] went forth with *Tezcatlipuca napatecli* for his god. The people went forth of *Tacuba*, and *Culucan* and *Ascapuzalco*, which was called *Tenpanecas*,[36] and these took as their god *Ocotecli*, which is fire, and for this reason they are accustomed to consume in the fire all whom they capture in war. These people, say the Mexicans, and no more sallied forth, although those of *Tuzcuco*[37], and *Tascala* and *Guejoçingo* boast and vaunt themselves that they too came when the others came from Mexico, and are also of that land. All these people with their gods set out in this first year, which was *tecpalt*, and there went forth of them forty bands.

Chapter 11th.

Of the Road they journeyed and of the Places they went, and of the Time they tarried in each Place where they were.

All having departed they came to two lofty mountains, in whose midst they encamped and remained there two years, and as the days are not painted that they occupied in reaching this spot, nothing appears more clearly than that up to the time of their resting in these sierras they reckon one year, and two years they spent there sowing what they had to eat and carry off with them, and here they erected their first temple to *Vchilobo*, according as they had done in that city.

These two mountains stood opposite each other, and their habitation was in their middle.

After three years had passed since their departure from *Astla* (*sic*), from when the Mexicans came forth, as has been told, they left the place or site of the two hills where they had remained two years, after having built a temple to *Uchilogos* (*sic*), as has been said, and came to a valley where there were many great trees, which they named *Quausticaca*,[38] on account of the many pine trees that were there, and there they stayed a year, which completed the four years since they had left their homes.

Thence they traveled onward till they came to a place which they named *Chicomuztoque*,[39] and they settled there and remained nine years, and so here they completed the thirteen years from the time of their departure, and when they left there they laid the place waste; and there was born in this place, *Tlacuxquin*, and *Mançamoyagual* and *Minaqueciguatle*, who were the two males, and one woman, their chief personages, and here was accomplished the thirteenth year of their exodus, and they began to reckon the second thirteen.

When they had departed from *Chicomuztoque* (*sic*), they came to a plain, which is the spot where at the time dwelt the *Chichimecas*, whose home was in front of *Panuco*, and here they remained three years, and to this valley they gave the name of *Cuatlicamat*. At the end of the three years they went forth and came to a ranche which they called *Matlauacala*, where they dwelt three years, and erected a temple to *Vchilogos*, thence they came to another ranche, named by them near the one where the *Otomies* lived, the indigines of the land; and here they rested five years, and erected another temple to *Vchilogos*, and here was fulfilled eleven years of the second thirteen since their departure.

From this sojourning place they came to a mountain opposite *Tula* named *Coatebeque*,[40] and when they came the *Maçeguales* held in great veneration the mantas of the five women whom *Tezcatlipuca* made, and who died the day the sun was created, as has been said, and from these mantas the aforesaid five women came again to life, and wandered in this mountain, doing penance, drawing blood from their tongues and ears; and when four years of their penance had passed by, one named *Quatlique*[41] who was a virgin, took a small quantity of white feathers and placed them in her bosom, from which she conceived without having known man, and there was born of her *Vchilogos*, for a new birth, in addition to his other nativities, for he was a god all-powerful, and could do whatever he wished.

And here came again to life the 400 men whom *Tezcatlipuca* created, and who died before the sun was made, and when they saw the woman was pregnant, they sought to burn her, but *Vchilogos* was born of her fully armed, and slew the whole of the 400 men; and this the feast of his nativity and the slaughter of the 400 men they celebrate every year, as will be narrated in the chapter relating to their festivals; and before the feast there is a great general fast who shall participate, lasting eighty days, during which they only eat once a day; and these 400 men whom *Vchilogos* slew, the inhabitants of the province of *Cuzco*[42] burnt up and took for their gods, and reverence them as such down to the present day, and in this way they celebrated for the first time the festival of the birth of *Vchilogos* and the massacre of the 400 men by him.

When thirty-three years had elapsed since their departure from their home, they went forth from *Coatebeque* and came to *Chimalcoque*, where they remained three years; thence they came to *Ensicox*, where they dwelt another three years, and built a temple and placed the mast of *Vchilobos* (*sic*); and after the thirty-ninth year from their departure they

drew out the mast of *Vchilobos* (*sic*), and gave it to *Vingualti*, to carry it with the greatest veneration on their journey, and they came to *Tlemaco*, which is near to *Tula*, and raised a temple to *Vchilogos* (*sic*), and remained there twelve years, and these twelve years being passed, they departed thence and took up the mast of *Vchilogos*, and gave it to *Caçiçi* to carry. And after all this had happened, they came to *Tlitlalaquia*, a well known town, and it was on the borders of *Tula*, where they rested two years and built a temple to *Vchilogos;* and after these two years the Mexicans came to the town of *Tula* itself, which in these days was peopled with its aborigines, who were the *Chichimecas*, and when they came to the said town they erected a temple to *Vchilogos*, and placed before it the candelabras that are now in use, in which they placed cepal and other savory things; and as soon as the Mexicans had come *Vchilogos* appeared to the inhabitants of the country in a black form, and they heard *Vchilogos* wailing beneath the earth, and they asked wherefore the god of the Mexicans was weeping below the ground, and the answer because every inhabitant of *Tula* was doomed to death. Four years later, an old woman, a native of *Tula*, went about giving out flags of paper fastened to rods, and making it manifest to them that they should get ready to die, because their time had come; and presently they all cast themselves upon the stone on which the Mexicans were wont to offer up their sacrifices, and the one of them who took charge of the temple which was in Tula, by name *Tequipuyul*, who was a stranger and a vagabond without employ, and whom they believed to be the devil, slew them all; and before the Mexicans erected their temple, that stone was a temple to the inhabitants of Tula; and so were put to death all the inhabitants of Tula, so that not one remained alive, and the Mexicans were lords of Tula.

Departing afterwards from Tula they came to the place where now stands the town of *Atotoniltengo*, where they remained one year, and thence they came to the town of *Tecuzquiciac* where they rested four years; thence they came to the town of *Apazco*, and from *Pazco* (*sic*) to *Zumpango*, where they stayed three years, and as they arrived near the town of *Çumpango* (*sic*), they encountered one sole *Chichimeca*, named *Tlavizcal Potongui*, who went out to meet the Mexicans, as he saw them coming; and they sacrificed to *Vchilogos*, god of the Mexicans another *Chichemeca*, whom they had made prisoner in battle, and they placed his head upon a pole for which reason this town is called *Zumpango*, which signifies a pole that transfixes human heads. Thence after four years they departed and came to *Tlilac*, where they tarried seven years, and leaving there, as they were on their road to *Clautitlan*, they lost one of their women who had been captured by the *Chichimecas*, and taken to *Michuacan*, and from her were born all the dwellers in *Michuacan*, who before that time were all *Chichimecas*, and they pursued their road to *Quatitlan*, where they were one year. Thence they proceeded and come to *Ecatebeque*, where they stayed one year, and when they left *Catebeque* (*sic*), they reached *Nepopoalco*,

which signifies a narrow passage where a shepherd can count his flocks for here they took the number of those who came; and no one knows how many there were of them, nor is there any memorial of the number in their paintings. Here they built a house to *Cipan* and to *Xincaque*, who were those who took the census of the people as they came, and from here went forth three Mexicans, one named *Navalci*, another *Tenaçi*, and the third *Chiautotolt;* and these three went forth to settle *Marinalco*, a town that exists at this day; and being there the Mexicans built a temple to *Vchilogos* at *Çimalpal*, two leagues from the City of Mexico, and then the Mexicans gave the name of *Tlatlatevique* to a mountain near *Chimalpa*, and thence they came to another mountain named *Quatitlan* which is two leagues from Mexico, where they rested four years, and thence they came to a mountain named *Visachichitlan*, where at the present the inhabitants of the suburb of Santiago live, thence they came to the mountain called *Teubulco*, thence to *Tenayucan*, and here a leading Mexican died, *Tepayuca* or *Tehayuco*, which was his name, and they found a *Chichimeca* in this place for their ruler named *Tloçi;* here they raised a temple to *Vchilogos*, and sacrificed a woman and made a grand festival, taking her there highly ornamented, as was their custom when they offered up a woman-sacrifice. Having made the feast to *Vchilogos*, they departed and came to a mountain named *Tepexaquilla* where they settled for nine years; and when the nine years were passed, they descended from this mountain, and dwelt near a lofty rock which issues warm water, now known as *El Peñolcillo*, which divides the suburbs of Mexico and Santiago, and all was barren up to the said rock, and there flowed the stream of Chapultepeque, and they made a certain enclosed place of chalk and stone to keep these waters, and they dwelt by them for four years; thence they came to Chapultepeque, where they gave a direction to the stream, and placed behind it many rods with pennons such as the old woman gave to the people of Tula, when they wished to sacrifice themselves, for which see what has been already narrated; then the Mexicans ceased being in *Chapultepeque*, and went forward and came to *Tlachetongo*, which is now *San Lázaro*, near to *Tianguez* of the Mexicans, and thence they proceeded to the suburb called *Aqualcomac*, which is nigh to the said *Tianguez*, and thence to *Vetetlan*, and thence to *Izocan*, which is the road of *Cuyacan*, and thence they came to *Tenculuacan*, where at the present they make salt, and thence to a mountain named *Tepetocan*, which is near to *Cuyoacan* (*sic*), and thence to *Vchilobusco*, distant two short leagues from Mexico, named *Ciavuhilat* in the *Chichimeca* tongue, because it was peopled by them, and in their religion they worship *Vbuchilti*, who was the god of water; and this god of water met* the Indian who carried the mast and plumes of *Vchilogos*, and as he did so he gave him certain arms which are those with which they slay the water fowl, and a dart; and because *Vchilogos* was left-handed as well

* *Topô* means, first, to meet; second, to strike. It may be that it should read "touched."

as was the god of water, they said that it must be his son, and the four were close friends, and they changed the name of the town where they had met with him, which was formerly called *Vchilat*, so that for the future it was known as *Vchilobusco*.

CHAPTER

From thence they came to Culuacan, where they found for ruler *Achitometl*, and then they passed onwards to the mountain named *Visachitla*, which stands near *Estapalapa*, and from there they came to *Quesumalc*, where they dwelt three years; and thence they went to *Capulco*, and made a detour to *Tacuxcalco*, which is the road of *Talmanalco*, where they built a temple to *Vchilogos*, and all the Mexicans assembled together at this place, *Tacuxcalco*, *Xinteça* and *Caley* and *Escualt*, being their war-chiefs, and they spoke to all the people; and because the *Chichimecas*, the aborigines of this land would not join themselves against them, but divided themselves off into many places, and in order not to be recognized altered their fashion of wearing the hair, so it was all done; because as they said *Vchilogos* had commanded them to act in this manner, and every one of those who went away, carried off his weapons, and those who remained took the plumes and deer skin of *Micoatl*, and his darts for arms, and the sack into which he was in the habit of throwing wild figs, because in those days people ate nothing else; then they kept on still farther to adjoining places in the neighborhood, and the war-chiefs addressed the people, telling them that four years they had to be dispersed, hidden and at the end of the said time they should all be reunited at *Cacaquipa*; and when the four years were passed they came together and returned to the mountain and bridge[43] of *Chapultepeque*, and there they captured *Copil*, the son of the woman whom the *Chichimecas* had taken prisoner, whence descends the people of *Mechuacan*, and they offered him up as a sacrifice, tearing out his heart towards the sun, and they remained dwelling in *Chapultepeque* fifteen years.

CHAPTER

Whilst they remained in *Chapultepeque* they had three war-chiefs,[44] one named *Clautliquecçi*, son of the chief who brought them, and was known by the same name, as has been told, and *Acipa*, son of *Çipayiavichiliutl*, son of *Tlauizcal Potongui*, and they chose this latter as their ruler to rule over them, and he governed them all the fifteen years they were in *Chapultepeque*. This *Vichiliutl* (*sic*), had two daughters, one named *Tuzcasuch*, and the other *Chimalasuch*; and, as we have already narrated, there was sacrificed in *Chapultepeque*, a son of the woman whom the *Chichemecas* took to carry off to *Mechuacan*, whence are descended those of *Mechuacan*, so they say that in this place also the aforesaid son of the said woman came to Mechuacan to see two Mexicans,[45] and when they wanted to sacrifice him, he said that he was not to be sacrificed except in *Mechuacan*, where his mother was, so over that they had

a fight by command of *Vichiliutl* and *Quatliqueçi*, and conquering him offered him up for sacrifice, and buried his heart in a place called *Temestitan*, which was a City of Mexico, afterward founded in this place, and the head they interred in *Tluchitongo*.

CHAPTER

These nine years being passed, they rested likewise twenty-five years additional in peace and quiet, *Vichiliutl* governing them, and they built on the hill of *Chapultepeque* a grand temple to *Vchilogos*; and while they were here, the Mexican aborigines, who were all *Chichimecas*, joined themselves together and assaulted them, and sat down their camp to besiege them near to the southward of *Chapultepeque*, and when night came on they fell upon the Mexicans and slew them, so that but few escaped by flight and took refuge among the canebrakes and recesses of the lagoon which was near by; and they burnt the temple which had been built, and the people of *Caltoca* captured the two daughters of *Vchiliutl*, and carried them away captive; and also was *Vchiliutl* taken prisoner, and the men of *Culuacan* slew him after he was captured; and those who fled and escaped were hidden for eighty days in the canebrakes, and ate nothing but herbs and vipers, and they bore with them *Vchilogos* being (*here occurs apparently a lacuna in the MS.*).

CHAPTER

We have told how the heart of *Copil*, the son of the woman who went to *Mechuacan** was interred at *Tinustitan*, and the reason why was that one day when *Coautliquezçi* was standing beneath a hut built of branches there appeared before him *Vchilogos*, and ordered him to bury the heart in that place, for in that place was to be his home, and he went there for that reason, and was buried there.

CHAPTER

When all the aforesaid had taken place, the Mexicans who had been in hiding among the canebrakes and herbage were driven out by the great hunger they felt, and came to *Culuacan* to seek for food; and they told the people of that place when they reached there that they had come to serve them, that they should not slay them, and they prayed to *Vchilogos*, for him to give his orders that they should not be put to death; and they gave to the men of *Culuacan* the plume and the staff of *Vchilogos*, and remained in their service. In these days *Achitomel* was lord of *Culuacan*, and *Chalchiutlatonac* the chieftain, and they had a very fine temple in which the people of *Culuacan* celebrated a feast to *Çiguacoatl*,[46] the wife of the god of the infernal regions, whom the people of *Culuacan* reverenced as their especial god.

CHAPTER

For the space of twenty-five years the Mexicans remained under the dominion of the people of *Culuacan* during which time the people of *Cul-*

* Mechoacan, El tierra de pescado (Garcia, v, 325).

uacan waged warfare against the people of *Suchimilco*, and in order to prove if the Mexicans were really warriors, they ordered them to go with them to help them; and the Mexicans thinking they were regarded as women, sent ten Mexicans, and no more, with them to the war, and the remainder stayed in their houses, which they possessed in *Tiçapan*[47], at that time a domain of *Culuacan*, and they gave orders to the ten men who went, that they should not slay any of the Suchimilcans, but that they should make them captives and cut off their ears; and the ten Mexicans did as they were directed so well, that they made prisoners of eighty of Suchimilcans, and from whom they cut off the ears, and from this the men of *Culuacan* recognized that the Mexicans were men of war.

CHAPTER

At the end of the aforesaid twenty-five years the Mexicans left a temple which they had built to *Vchilogos* in *Culuacan*, and erected another very large one at *Tiçapaa*[47], and when the Culuacans saw so grand a temple they asked the Mexicans what they were going to have in that temple, and what they should place in it; to which they were answered *hearts*, and when the Culuacans heard this reply, they threw straw and filthy things into the temple, mocking at the Mexicans. Then the Mexicans[47*] who was called *Avençi*, and sacrificed her to *Vchilogos* smeared blood on the walls with one of her legs; and when the *Culuacans* saw this sacrifice they were astounded, and arose against the Mexicans, and they all ran near to *Catitlan*, a river which flows close to *Culuacan*, and kept on flying all the way to *Nextiquipaque* in which place at this day there are ten households that are subject to Mexico, and *Coxcoçi*, chief of *Culuacan*, looked favorably upon the Mexicans, and because they had risen against the Mexicans, he slew many Culuacans.

CHAPTER

When all the aforesaid twenty-five years already written about had elapsed, there began the first year in which they commenced to enter into the bounds of *Tenustitlan*, Mexico, and to populate it, and they came to *Istacalco*, which is a country near Mexico, and thence they went to *Mixuacan*, where a woman bore a child to which they gave this name, which signifies the fertile, and from there they settled in a suburb named *Temazcaltitlan* which signifies the suburb of the bath, and is in these days the district and suburb of St. Peter and St. Paul, and in the place it said that some Mexicans who carried *Vchilogos* went astray, murmured against him, and *Vchilogos* told them in their dreams that things must be as they had been, but that they were near to the place where they were to take their final rest and home, and that those who had murmured against him had sinned like men of two faces and two tongues; and in order that they should obtain pardon, they made themselves a head with two faces and two tongues, and having made the head of it of the grains that they ate, they shot arrows at it, and covering up their

eyes, those who had shot at the figure, sought to find it, and finding it they ate it up, dividing it up among them all; and so it was performed, and they all came together and settled in *Tatilulco*, which was a small island, and is now known as the suburb of Santiago. In this first year in which the Mexicans came to the aforesaid place, *Vchilogos* appeared to one of them named *Tiunche*, and told him that his home was to be in this spot, and that the Mexicans would not have to wander any farther, and he should tell them that when it was morning they should go seek a man of Culuacan, because he had abused them, and take him and sacrifice him, and give him to the sun to eat. So *Xomemitleuts* went forth and found a man of *Culuacan* named *Chichilquautli*, and sacrificed him to the sun on going out; and they named this place *Quanmixtlitlan*,[48] which afterwards was called *Tenustitan*, because they found there a wild fig tree grown on a stone, and the roots thereof grew forth out of the place where lay buried the heart of *Copil* as has been already narrated.

Chapter

In the second year of the settlement of Mexico the Mexicans began to lay the foundations of the large and important temple of *Vchilogos*, which kept on increasing at a great rate, for every ruler of the dwellers in Mexico who succeeded another in power added to it a building equally as large as the original one which the first inhabitants had erected there; and this the Spaniards found very tall and strong and broad, and it was much to look at.

In these days the Mexicans had for their ruler *Illancueitl*, a woman of importance who had power over them; and she was the wife of *Acamapichi*,[49] a native of *Culuacan*, and she was of *Coatlixan*, and although of *Culuacan*, descended from the Mexicans, for her mother married there one of the chief men of *Culuacan*, and the mother was a Mexican; and her husband, at the suggestion of his wife, came to Mexico, and she told them that as he was of the best family and they had no lord, they should take him for their ruler, and so he was the first ruler, and his wife died in twenty-fourth year after the foundation of Mexico; and after her death they chose him for lord because in her life he was only looked upon as the chief man;[50] three years before this, which was reckoned as twenty-one years from the foundation of Mexico, the Mexicans made war upon the people of Culuacan, and burnt their temple. In the next year, the twenty second from the foundation of the city, the Culuacans took notice of the great progress the Mexicans had made in those twenty-two previous years, and were smitten with fear, and placed their gods in a canoe with which they went to *Suchimilco;* and when they had reached the town of *Quantlecaxtan*, the sun shone forth with so much brilliancy that his rays struck them blind, and so they could not see until they had come close to Mexico; and when they had recovered their sight they placed their gods in Mexico, and built for them a small temple a short distance further on than the place where now stand the shambles.

In the twenty-eighth year from the foundation of the city in which the fifty-two years were fulfilled, there was held a great public festival in which all light was extinguished throughout the land, and when it was all extinct they would draw fire anew from the mountain of *Estapalapa*. This festival took place from every fifty-two to fifty-two years, so that the year that completed the four times thirteen years was the fifty-second one.

At the thirty-first year from the foundation of the city fire first began to issue forth from the volcano, and in the forty-seventh the Mexicans conquered *Tenayuca*, and burnt its temple, which was of straw, and the people of *Tenayuca* were *Chichimecas*.

In the fifty-second year of the foundation of the city the people of *Tatilulco* petitioned for a ruler *Teçuxomutli*, the lord of Escapuçalco, and he gave them for their master *Teutleuac*, whose rule did not endure forty days, for he bore too hardly upon their braves, and they helped him in no manner. *Teçucumutli*, who was a Mexican, was chosen for their lord by those of *Escapuçalco*, as one of the two which it was their custom to have, and they have always had that number, and have to this day.

Quaquanpuanaque was the second ruler of the Tatilulcans whom the lord of *Escapuçalco* gave them; his reign lasted fifty days, at the end of which time they fled away from him; he is represented with claws on his feet. In the fifty-third year of the foundation, *Acamapichi* was made ruler of Mexico. In the fifty-sixth year the Mexicans made war upon the *Suchimilcans*, and burnt their temple; and in the year 59 *Acamapichi* conquered *Mezquiqué*. In the year 63 from the foundation of the city there went forth from Mexico forty men and women by *Guaximalpan*, and the *Otomis* of *Matalçingo* found them, and slew them by treachery in *Cuitralavaca* (*sic*).

In the seventieth year from the foundation of the city *Acamapichi* conquered *Cuitralavaca*, and burnt for them their temple. In the seventy-third year Lord *Acamapichi* died, and they made *Vichilivci*, the son of Acamapichi, their ruler. In the year 75 *Miciuçiziuci*, the daughter of *Escoaçi*, lord of *Cuernavaca*,[51] wife of *Vicilivçi*, bore *Mutiçuma*, the elder, who first was called *Iluican Minaçi*, and afterward *Mutiçuma*; because his father was lord against the will of very many people, the son changed his name into *Mutiçuma*, which signifies *angry lord*. In the year 79 a sister of *Viciliuçi* married with *Istlisuchilci*, lord of Tezcuco, and bore *Neçavalcuyuci*, who became lord of Tezcuco. In the year 81 the Mexicans conquered *Quaximalpan* from the Otomies.

In the year 85 from the foundation of the city the Mexicans conquered *Capiscla*, and in the same year *Quauximilco*, in the province of Chalco, and in the next year they waged war against all the aforesaid peoples, and in that year they gave themselves up. In the ninetieth year from the foundation they conquered *Tezquiaque*. In the ninety-second year the Mexicans sent out seven of their chieftains to ascertain if the peoples of *Puchitlan* were for war, and as they passed by *Xaltocan* three of them were treacherously made captive and murdered, and the other four escaped by

flight. In the next following year they conquered the province of *Tazcuco*, and they began upon *Tepepan*, much against the wishes of its ruler, who, when he saw them, went away and fled to *Tezmuluco*, a town of *Suyocingo;* the father (*here occurs a lacuna*) being dead, because they were at peace with the Mexicans.

In the following year 94, *Viçiluicin* died, and they took for their lord a brother of his named *Chimalpupucaçi*. In the year 97 the people of *Tuzcuco* gave themselves up to *Chimalpupucaçi*, and in the same year they captured Tulançingo, and the Mexicans were a whole year in making themselves masters of it. In the year 99 the people of *Tatiluco* fled to *Tula*, and as they had died out, and had left their god, named *Tlacauepan* there, so they took him and carried him to *Tatilulco*. In the year 105 from the foundation of Mexico, *Teçocumuc*, lord of *Escapuçalco*, died, and as *Maxtlato*, son of *Çocumuc* was lord of *Cuiuacan* in the lifetime of his father, and as his father was now dead, he came to be lord of *Ecapuçalco;* and this one gave orders that there should be a general uprising against Mexico, and when *Ximalpupacaçi* saw that the land was in rebellion, he slew himself, and being dead the Mexicans chose as their lord one of his brothers named *Izcuaçi;* and when *Tlacateulti* lord of *Tatilulcoco* saw the great force and command that the lord of *Escapuçalco* had, he fled away from him, but to no avail, for he was captured near the fountain of *Saltoca*, and there they slew them; and it was because formerly, when he was lord of *Escapuçalco*, the lord of Tatiluco seduced his wife, and for that reason the captive was ordered to be slain; and in this year *Neçagualcuyuci* fled from *Tezcuco*,* because the Tezcucans were in revolt against Mexico. In the following year 106, the natives of the country endeavored to make war against Mexico, by order of the lord of *Escapuçalco*, but one of the chiefs of *Escapuçalco*, named *Totolayo*, made peace with Mexico in the year 108, and the inhabitants of Mexico would not permit of a peace unless they slew the lord of *Escapuçalco*, and seeing how on account of their desire for a peace they could do no other thing, they caused him to be slain, and so it was done (*In the year 109 Tatilulco rose in revolt*), and in the year 112 they came into conflict with the Mexicans. In the next year, 113, *Quautlatoaçi*, the lord of *Tatiluco* (*sic*), revolted against Mexico, and one night in his dreams there appeared to him one of the gods they worshiped who told him he had done wrongly, and for this reason he rendered himself up at Mexico, and the Mexicans were unwilling to slay him, so they handed him over to his own people that they might put him to death, and so they killed him. In the 117 the Mexicans gained *Guautitlan*, and in the next year *Izcoaci* died, and they raised to be their lord *Mutiçuma*, the elder. In the year 125 of the foundation of Mexico, *Vchilobos* (*sic*), renewed himself, and made himself enormous.

In the 128 at the Easter-of-Bread season there fell such a terrible hail, and so much of it that the houses were destroyed and fell in ruins, and the lagoon froze up. In the year 132 there was terrible hail and famine, so much

* *Tetzcuco*, (Molina); *Tetzcoco* (Buschman, 607).

so that in the next year it was ordered that if one took but a thread of maize, even if the maize field belonged to him, he should die for the act. In the year 136 *Motecuma* the elder, having made a round buckler (or disk*) of stone, the same which Rodrigo Gomez drew forth, caused it to be buried at the door of his house, and placed a hole in the middle of it, and it was a very big hole, and in that hollow they placed the captives taken in war, fastening them to it, so that they could command only their arms, and gave them a shield and a sword of wood, and they brought in three men dressed respectively as a lion, a tiger, and an eagle, and all these fought the prisoner, and wounded him; then they took a large knife and cut out his heart; they made these knives out of stone, under this enormous large and round stone; and afterwards the others who were lords of Mexico made two other stones and placed them, each lord his own, one over the other, and the one they took away[52], and it stands to this day underneath the baptismal font; and the other was broken up and burned when the Spaniards entered, and the very first persons who used this stone were the people of *Cuaistravaca*.

In the year 139 *Cruistravaca* was taken, and much precious stones were brought to *Mutecuma* In the year 141 the Mexicans took *Quetlasta*. In the year 147 *Motecuma* (*sic*), died, and *Axayacacin*, his son, was raised to be lord. In the year 151 *Mochiuci*, the lord of *Tutilulco*, surrendered himself to Mexico, and in the next year the people of *Quetlastla* revolted on account of the annual tribute of twenty men, and they took refuge in a house filled with red pepper (*agi*), and consumed themselves with fire; but soon in the year 153 they were subjugated. Next year *Axayacaci* made *Citlalcoaci* the lord of *Malinalco*. In the year 155 *Axaycaci* seized three men himself, and was wounded, and so he personally gained *Matalcingo*. The following year, 159, *Axayacaci* died, and they made his brother, *Tizcocicaci*, lord of Mexico.

The following year, 160, they endeavored to make Vchilobi very large, and almost all, even to the infants, set to work on him. Next year they held a festival in the temple of *Vchilovi* (*sic*), with the blood of the *Matalcingos* and *Tlaulans*, for they slew many of them. In the year 164 *Tizcocicaci* died, and his younger brother *Auicoci* was raised to be lord of Mexico. Next year *Vchilovi* (*sic*) was finished by *Auicoci* and he sacrificed many people on that occasion. In 176 the water rose so high in the lake, especially the river of *Cuiuacan*, that all the houses were drowned, and the water came up to the first circle of *Vchilobi*, and the houses which were of adobe fell in; and it is said that the water that rose was black and full of vipers, and it was looked upon as a miracle. In 180 *Aucoci* (*sic*), died, and was succeeded by his brother *Mutecuma*, who was the last lord. In 182 *Mutecuma* built a temple to *Quicalcoatla*, where, at the present time, stands the house of the bishop, and covered the roof with straw. Next year the lightning fell on it, and consumed it, 'twas said that the bolt was sped by *Tlaloque*, the god of water. They built a very large temple to the honor

* *Rodela.*

of *Çintelil*, the son of *Piciutetl*. In the year 184 the inhabitants of Mexico slew many of those of *Çoçola*, whom they had captured in war; having stretched them out on two pieces of wood in the form of a St. Andrew's cross, they shot them to death with arrows, and every year they celebrated this festival. In the 185th year from the foundation of Mexico, the fifty-two years were completed, and *Muteçuma* celebrated the festival for the last time. In the 189 there appeared an omen in the heavens, which arose from near the summit of the volcano and floated on high over the city, and it was of a white color as broad as two arms; and *Moteçuma* endeavored to discover what this thing might portend, and his wise men responded that it foretold his decease in that year, and it turned out that this was the very year in which the Christians appeared on their journey to this land. In the year 193 the *Tascalans*[52]* laid siege to *Guaxocingo*, and they were reduced to great straits through hunger, until *Muteçuma* brought them assistance, and took some of them to Mexico, and others of them he placed there for his defence; and they prayed to *Camastle*, their god, and after that they had made an end of prayer, they rose in revolt so that the Mexicans let go their prisoners and returned to the city; and the people of *Guaxocingo* slew the Mexican women who had intermarried with the men of *Guaxocingo*, and all their sons, because they were of Mexican blood.

In the year 196 in *Guaçacalco* (*sic*), came two ships which were received at *Vera Cruz de Paz*, to spy on whom *Muteçuma* sent one of his people, and soon *Muteçuma* said that these were his gods; the ships remained at *Guaçacualco* (*sic*), and said they would return a year later;[53] the day they arrived at *Guaçacalco* was called *centochil;* the port of Vera Cruz bore the name of *Chalchuecan*. In the year 197 came the Marquis to New Spain to whom *Muteçuma* sent an envoy to Vera Cruz with many shields and plumes, and a sun made of gold, and a star of silver; they made themselves understood by the Indians by means of an interpreter named Marina.[54] Afterwards the Marquis came to *Cempoal*, where they received him with trumpets. Thence he proceeded to *Tascala*, where the warriors sallied forth to battle, and all who came forth were slain; and he being informed that the Tascalans desired to massacre the *Chululans*, he joined with them in another place and slew them all. It is said that whilst the Marquis was in *Chulula*, he sent *Alvarado* to the province of *Chalco*, who returned with the information that the land and the people were both bad, and that he should turn back; on which *Tamaya*, the lord of *Çempoal* said that he had better march to Mexico, where *Muteçuma* lived very richly, and that everything he owned was made of gold, and that he styled himself lord. The Marquis was forty days in Chulula. Then there came on the behalf of *Muteçuma*, *Viznagual*, the father of *Tapia*, who was with the Marquis, to tell him by the orders of *Muteçuma*, that he would give him much gold and silver if he would turn home again; him the Marquis caused to be seized which caused great fear to Muteçuma. (In this year 198 was held the festival of *Vehilobi*), and *Muteçuma* died from the effect of a blow with a stone thrown by one of his

own subjects, who would not listen to him, but used opprobrious language to him; and they put in their *Vchilobi* beams, and the bravest soldiers whom the Spaniards were unable to rescue when they left the city, and who were all put to death. One night the Marquis left the city and went to Tascula, where he was received by its lord, *Xicotenga*.

On the death of *Mutecuma*, the Mexicans chose for their lord *Cuitlavaçi*, lord of *Estapalapa*, a brother of *Mutecuma*, he ruled eighty days, the smallpox[55] broke out throughout all the Indians, and many perished before they returned to subjugate the city.

The Marquis came to *Tezcuco* having conquered all the land in its vicinity, and the people of Chalco made war on it; while he was in Tezcuco, *Guatemuça*, son of *Viçoçi*, was chosen lord, and he made war on Chalco, and without cause he slew six of their chiefs (in the year 199). It took the Marquis eighty days to conquer his way to Mexico. The Marquis made *Istisuchl* lord of Mexico, who in the year 200 died, lord of Tezcuco, and *Juan Velasquez*, deposed him, and reigned eighty days. *Guatemuça* was made lord of *Tatilulco* (year 201), and presently sent to all the surrounding people to call them to a war against Mexico; and these people came at once and informed *Juan Velasquez* of the matter, and he said it made no odds to him, for he was not its lord. The Marquis left new Spain in peace and went to Honduras (called in Indian *Guaimula*), and left his subordinate deputy, *Peralmildez*, as Captain-General, and returned to Castile. Don *Martin*, son of *Mutecuma* (year 202), and the deputy who were named in place of the Marquis, made requisitions on the Mexicans for gold and silver, and they put to the torture one Rodrigo De Paez, because he would not tell where the Marquis kept his gold and valuables, and finally as he would not give them the information, they hung him (year 203); when the Marquis returned, he seized the factor and overseer, but did not punish them as they had deserved, but sent them back to Spain (year 204). The Marquis made *Tapia*, Governor of Mexico, his Deputy, and in this year 295, *Nuño de Guzman* came to Panuco. The Marquis departed for *Castile*. In the year 206 there were rains of bloody drops, and it was the Sabbath about two o'clock, and everybody saw them, and in this year there appeared an omen in the sky of a white color, and shaped like a lance. In the year 207 *Nuño de Guzman* left for *Neuva Galicia*, and the four councillors of Castile came, *Salmeron*, *Maldonado*, *Çainos* and *Quiroga*,[56] they made Don *Pablo*, Governor.

[NOTE BY H. P., JR.—*Here follows what should have been a chapter by itself, being entirely disconnected from the subject already treated of. The historical part has come to an end, and this seems like an addition by another hand, being somewhat of a repetition of matters previously touched upon.*]

They calculate their year from the March equinox, when the sun casts a direct shadow, and as soon as they can notice that the sun is beginning to rise[57] they count it as the first day, and from the twenty to twenty days, which make their months; they reckon their year, with five days omitted, so their year only comprises 360 days; and from the day which was the

equinox they reckon the day of their feasts, and so the feast of bread, which was the day of the nativity of *Vchilobi* from the plume, was the day when the sun was in declination, and so as to the other festivals.

The Mexican Indians believed that in the first heaven there was a star, *Çitalmene*,[56] which was a woman, and *Tetal Latorras* (*sic*), who was a male, whom *Tenacatecli* (*sic*) made for guardians of the skies, and the woman never is seen because she is on the road that the heavens make.

In the second (*heaven*) they say there are certain women who have no flesh whatever, but are all bones, named *Teçauçigua*,[57] and otherwise called *Çiçimine;* and that these are placed there so that when the world comes to end, their duty will be to eat up all the men.

And when the old people are asked when the end of the world shall come, they say they don't know unless it is when the gods themselves shall all become extinct, and *Tlazquitlepuca* (*sic*) shall carry away the sun, and then all things shall pass away.

In the third (*heaven*) are the 400 men whom *Tezcatlapuca* (*sic*) created, and who were of five colors, yellow, black, white, blue and red, so these kept ward in the heavens.[22]

In the fourth were all manner of birds who from thence descended to the earth.

In the fifth were vipers of fire, whom the *Fire-god* had made, and from them issue the comets and omens of the heavens.

In the sixth were all the winds.

The seventh was full of dust which thence came down on earth.

In the eighth all the gods came together, and from there no one could ever ascend higher, to where dwelled *Tenacatli* (*sic*) and his wife; and no one knows what is in the rest of the upper heavens.

Being questioned as to the sun's whereabouts, they replied that he dwelt in the air, and traveled in daytime and not at night, because he returned to the east when he had reached the summit at midday, and that his light then was that which already shone forth towards his setting-place; and that the moon is always traveling after the sun, and never catches up with him.

Being questioned as to the matter of thunder and lightning, they said that the Water-god had many subjects made by him, who carried each one an earthen money-jug[13] and a rod, and that from these earthen vessels they cast down the rain, and that the thunder was when they struck the vessels with their rods, and that the lightning flashed from these vessels.

The people of *Culuacan* say that they came, conjointly with the Mexicans, to Tula, and there they split and went direct to *Culuacan*, and thence to *Suchimilco* and *Malinalco* and *Ocuyla*. These four towns they settled and on the way peopled *Cuitralavaca*, and so 120 years passed away, and afterwards the Mexicans came and arrived at Chapultepec, as has been said, and waged war on the people of Culuacan.

In the histories of Mexico, represented by Indian paintings, are shown many naked Indians, at whose beginning are some clothed in plants,

thereby meaning to convey that when they fled to Mexico they were dressed in that manner, and that they subsisted on what they could obtain by fishing, and that they had to undergo great hardships; and they paint no more valiant warriors. And these were forty years without a lord. The first lord of the Mexicans was named *Acamapichil*, who lived twenty years. In this time it happened that two women misbehaved,[59] the one with the other, and they stoned them to death close to *Escapuçalco*, which is called *Teculuapa;* before this judicial act was performed, the lord of *Escapuçalco* reported it to him of *Guatlinchan*, and the two reported it to the lord of Mexico, and all of them ordered it to be done. And likewise came to pass that *Xilot Iztac*, daughter of *Anil Mixtli*, was married to the brother of the lord of *Ascapuçalco* (*sic*), and when he died his brother, the lord of *Ascapuçalco*, took her for his wife; and she went off to Suchimilco, and did wickedness with Ananacalt, and when it became known to the three lords, they took them and stoned them to death. They say it was the custom that a brother's widow could not lawfully remarry except with a surviving brother, and if she married any one else she forfeited her lands and all her possessions. The first lord of *Ascapuçalco* was named *Teçoçomucli*.

At this very same time it came to pass that two lads stole the grains of maize that had been sowed in the earth, and they were taken and sold for slaves, and the price paid for each one was five mantas.

And in these days it happened that a woman stole certain maize from a granary, and a man saw her and told her that if she would let him lie with her he would not inform on her, and she did so; but afterwards the man accused her of the deed, and the woman confessed all that had taken place, whereupon she was acquitted, and the man was given as a slave to the owner of the maize.

At this time it happened that two lads robbed five ears of maize before it had ripened, and they were ordered to be hung, as it was a greater crime to take them before they were mature than afterwards. And when the first lord of Mexico was dead, the Mexicans remained three years without a ruler, after which they chose *Viçiliutli*, son of their first lord, who lived twenty-five years. In his time it came to pass that a man of Tezcuco kept a watch over his wife, and three days after her confinement he caught her with the sacristan of the temples, and he seized them and the three lords condemned them to death. And it also happened that a man found his wife with another man, slew the man and not the woman, and she came back to live with her husband, for which reason both she and he were put to death.

When the second lord died the Mexicans chose *Chimalpupuca* for their ruler, who lived eleven years. In the days of this third lord it happened in *Chimaloacan* that a woman saw a drunken man and went to him and lay with him, and for this they stoned the woman, but inflicted no punishment whatever upon the man.

And at this time it happened that a man of *Tenayuca* had a granary of

maize, and a man from *Guatlitlan* robbed him by an enchantment cast upon it, for he fell into a deep sleep by this contrivance, and the man and his wife took all they found; and when this was known to the three lords they were both condemned to death, the man and his wife.

He who stole a hen was enslaved, but he who took a dog was not punished, for they said that the dog had teeth wherewith to defend itself.

When the third lord died the Mexicans elected to that power *Izcoaçi*. And at this time the *Escapuçalcans* commenced a war against the Mexicans, and called on the people of Tezcuco and *Tultitlan*, *Quautitlan*, *Tenayuca*, *Tlacuba*, *Atlacubaya*, *Cuhuacan*, *Culiacan*, *Suchimilco*, *Cuitlavaca*, and *Mizquique*; all these peoples marched against Mexico, and were vanquished.

Whilst the Mexicans were ruled by lords that part of *Tatilulco*, which now is known as *Santiago*, was likewise under rulers, for whilst *Acamapichil* and *Vichiliuitli* reigned in Mexico, which was for forty years, in Tatilulco ruled *Quaquapuauaque*, the father of the lord of *Escapulçalco*; this latter was for two years ruler of Mexico before they had a lord in Mexico; he lived forty years. And while there ruled in Mexico *Chimalpupuçi* and *Izcoaçi*, there reigned in *Tatilulco*, *Tlacateuçi*, son of the first, who lived twenty-three years. Whilst *Muteçuma* the elder reigned in Mexico, in *Tatilulco* ruled *Quatlatloaçi*, son of *Tlatecuçi*, and he slew the former, and lived thirty years. Whilst in Mexico ruled *Axayacaçi*, in *Tatilculco* ruled *Moquiuiçin*, brother of the last, and married to the sister of *Axayacaçi*, and on her account there was war between the two because she gave out her husband was a man of war who had conquered the Cotastans and Mexicans, and on that account his neighbors hired his services. Whilst *Teçiçicaçi* ruled in Mexico, in Tatilulco ruled *Ouacoizçiçi*, *Tucaxcal Tecli* and *Tlaueloquiçi*, and *Tatilulco*. Whilst *Auçoçi* ruled in Mexico, in Tatilulco reigned *Çiquac Pupucu*, who was the son of *Tucatecal*, and son of *Quatlatoaçij*, and *Yulocoauiçi*. Whilst in Mexico *Muteçuma* then reigned, in Tatilulco there ruled *Topantemitçi*, *Ticoque* and *Aguatal*, grandson of *Muquiniçi* and *Yzeiaçi Tucuxcalcotlequinal*, and this one could not[59*] with *Muteçuma*. While *Muteçuma* and *Juan Velazquez* and *Tapia* were governors of Mexico, he who at first was not a chief personage in the time of the Marquis, *Don Juan*, was governor of *Tatilulco*, the father of him who is governor to-day, and he was a common man and maçegual of Mexico.

They held certain laws in war which they executed in grand style; and it was the custom that if the captains sent out a messenger and he did not tell the truth he died for that; and likewise they had another law that any one who should give advice to their adversaries should die for it; and likewise they slew any man who lay with a captive woman, and likewise he who was captured alive was slain. And if one captured a prisoner alive and another tried to rescue him, it was punished with death. In war-time they had five captains who at the same time were judges. There was a person who hunted up crimes and painted them, and gave the

information to the five lords jointly, and after consultation with the chief lord there were other five who carried into execution what the five had decreed.

There were other laws in their Tianguez or fairs which are as follows: If the son of the lord turned out a gambler and a swindler (*tahur*), and sold his father's possessions or other portion of land, he was secretly choked to death, and if he was a maçegual or fisherman, he was sold into slavery. Likewise, if one stole magueys to the number of twenty to make honey, they should pay as many *mantas* as the judges should ordain, and if the party did not own sufficient or if there were more magueys, he or they became a slave or slaves. Whoever should borrow mantas as a loan, and neglect to repay them, should be a slave. A theft of a fishing net was to be paid for in *mantas*, and if the party did not own them he became a slave. If one stole a canoe or vessel in which people went, he should pay the value of the canoe in *mantas*, and if he had not enough he became a slave. If a man lay with a woman slave who was under age he became a slave also with her, and if she became sick and died, he became a slave, and if she did not die he paid for her cure.

If any one brought a slave to *Escapuçulco*, where there was a slave mart, and the purchaser gave mantas for him, and the seller unfolded them and was content with them, if afterward he rued his bargain he should return the mantas, but the slave became free. If any one did not grow up to natural size, and the relations sold him, and it was known afterwards, when he had come of age, the judges should order as many mantas to be paid as to them seemed fit to give his owner, and the slave became free. If a slave woman fled away and was sold to another person, upon its being discovered, she should return to her master and the price be lost that was paid for her.

If a man lie with a slave, and she dies, being pregnant, he shall become the slave of her master, but if she conceive and bring forth a child, the child is free, and shall belong to its father.[60] If any conspire to sell a freeman for a slave, and the fact become known, all who took part in the affair shall become slaves, and one of them shall be given to the purchaser, and the others be divided between the mother of the person wrongfully enslaved, and the informer who discovered the transaction. Any persons who administer potions with intent to procure death shall be strangled for the same, but if the person murdered was a slave, the murderer shall become the slave of his master. If any one shall steal as much as twenty arribas of maize, he shall die for it, but if less he shall be redeemed by a ransom.

He who steals unripened maize shall be beaten to death with rods. He who steals the *yetecomatl*, a species of gourd fastened with thongs, and worn on the head with tufts of feathers, such as the lords wear, sprinkled with green tobacco, he who steals it shall be garroted to death. He who steals a chalchui, which was a string with certain computations forbidden to be owned by men of low degree, shall be stoned to death in the

Tianguez, wherever he may be. And he who in the Tianguez[61] shall steal anything from the dwellers within the Tianguez, shall be stoned to death. Highway robbers were also to be publicly stoned to death. Any priest who got drunk was to be slain in the house where he became intoxicated, and to be beaten to death with clubs; and the marriageable youth who got drunk was taken to a house known as *tepuxcali*, where he was choked to death; and any person of importance who held public office and got drunk, was deprived of his position, and if he was a warrior they took away from him the title of *valiant man*. If a father lay with his daughter, both were to be strangled to death by a rope passed around both their throats. He who lay with his sister was to be strangled with the garrote, a crime they considered detestable; and if one woman lay with another, they strangled them with the garrote. If a pontiff was found with a woman, they slew him secretly with the garrote or burned him alive, tearing down his house, and forfeiting all his possessions, and all who knew the matter and kept silence about it and concealed it, were likewise put to death. There was no punishment for adulterers unless they were taken *in flagrante delictu*, in which case when caught they were stoned to death publicly.

Chapter th.

Whence originated the Lords of Tochimilco.

The beginning of these lords was one *Yzcocutl* who came from *Tula*, and dwelt in *Atlixco* where they received him for their ruler, and afterwards he left them and settled in *Xuctectitl* and *Vepevcan*, now known as *Tuchomilco*, and there he died. His wife was named *Chimalmaçi*, and likewise she came from *Tula*. On his death his son *Tonaltemitl* succeeded him, whose wife was *Çalpaloci*, a native of Petlauca. On his death *Çintlavilçi* succeeded to his father's power, his wife was *Teyacapançi*; he was a native of *Cuyuacan*, and left sons, who, however, did not inherit his position.

On *Çintlavilçi's* death his two brothers, named *Yxteveyuçi* and *Çivacoaçi* succeeded him in reign, and they held equal powers; their wives were natives of *Vepetlavca*. On the death of these two lords they were followed in their seignory by two others, *Cacamaçi* and *Civacoaçi*; *Cacamaçi* was uncle of *Civacoaçi*, who was the son of *Yxteveyuçi*, and their wives were natives of *Vepetlavaca*. On the death of these two lords, *Cuapili* succeeded to the throne, and he was a grandson of *Civacoaci*; who was lord before the other two; and *Cuapili*, while still living, made his son, *Mixcoaci*, ruler of a certain portion of the people; the wives of the father and son were from *Petlauca*, and in the days of these came the *Xpianos*.* When these were dead, Don *Miguel* and Don *Juan* succeeded them, of whom Don Miguel was the more powerful; and he came to the seignory, because his uncle was *Cuapili*, and the former came forth in peace to the Christians, while the latter fled away. The Marquis made him lord with the consent of the people. Don *Juan* was his brother *Mixcoaci*, and for

* Meaning Christians?

this reason succeeded to the seignory; the wife of Don *Miguel* was of *Quizuquechula*, and that of Don *Juan* of *Aupetlavaca*.

Of the Manner in which they Reckon their Months and Days.

It is to be remarked that they consider twenty days as their week or month, counting in both the first and the last as being but one day, as if we should say there were eight days in the week, reckoning Sunday as both first and last. Also they count time from four years to four years, because they do not number their years higher. Also (*a lacuna*, * *)

In these festivals when the sacrifice is offered by the pontiffs,[62] they cover up their heads with certain white mantas on which they arrange white plumes, I mean on their heads, and they robe themselves in a painted shirt open in front, and in this manner they sacrifice.

Appendix.

Annotations and Corrections to the Codex Ramirez.

[1] *Tonacatecli*, called by Brinton (who follows the classical authorities) *Tonacatecutli* and his wife *Tonacacihuatl*. The name *Tonacatecutli* is supposed to signify Lord of our Existence, and *Tonaca Cihuatl* to mean Queen of our Existence. (Vide Am. Hero Myths, p. 73 and note.)

[2] There were two Tezcatlipocas, the red and the black, of whom the myths blended. (Brinton, A. H. M., 73.) The names of these four brothers are differently stated by various authors. *Tezcatlipoca-Camaxtli* was the spirit of darkness (eo. lib., 68). (*The shining mirror.*) Stone seats were placed around the streets for him to repose on, on which no native ever dared to sit. *Clavigero*, 1, 244.

His principal image was *Teotetl* (divine stone), black and shining like marble and richly dressed. He was called by Herrera (III, II, ch. XV) Tezcaltiputça; by Boturini (p. 11) Tezcatlipoca; by Garcia (IV, 300) Tiezcatipuca; *Titlacauan* was also one of his common names, meaning "we are his slaves." (A. H. M., 106.)

Of the three names, the one given by Boturini is correct. According to Mendoza (Anales de Museo Mexicano), the meaning of the word is brightness, darkness and smoke, being the silver resplendency of the moon illuminating the darkness of the night, breaking through a smoke-like obscurity.

Brinton (Am. Hero Myths, p. 71), leans to the more generally received interpretation of smoky mirror (from Tezcapoctli), meaning the rising of the mist from the surface of the waters. Tezcatlipoca was the god of gods, compared by Garcia to Jupiter, the supreme invisible essence, "the most sublime figure in the Indian Pantheon" (Brinton, lib. cit., 69); also the youth, omnipotent, exacting of prayer, creator and disposer of men; the enemy, the worker and night wind. The divine Providence according to Boturini. See note 7.

[3] *Camaxtli*. Also called Teotlamacàzqui (the hieroglyphic of the priests). Tezcatlipoca-Camaxtli the spirit of darkness. (American Hero Myths, Brinton, ch. 3. p. 68.) Titlacàhuan, we are thy slaves. (Bot. xi.) (Cf. Note 27).

[4] Quatzalcoatl (Bot. II.) Herrera 3, 3, *xiv*. Quetzalcoatl (Brinton A. H. M.), passim. Quetzalcohuatl (Bot. 25) hieroglyphic of the Air. Quetzalcoatl (Garcia, IV, VII, 262), was a "white man with a beard, of industry and intelligence, who fled from the tyranny of Huemac (*the great hand*), King of Tula, and took refuge at Cholulla. He is the spirit of light and culture, ever engaged in a continual warfare with his brother, Tazcatlipoca, the spirit of darkness. (A. H. M.)

Quetzalcoatl (Clavigero, 1, 248), "feathered serpent," god of the air.

Vetancourt (Clav. 1, 250). *Coatl*, a twin, *Quetzalli*, a gem.

Queçalcoatl, por otro nombre yagualleeatl. The name was applied to him in his relation to the winds, whose ruler he was, the words *Yahualli ecatl*, meaning "the Wheel of the Winds." *Yahualli* is from the root *yaual* or *youal*, circular or round, and the towers where he was worshiped were of this form. (A. H. M., 121.)

[5] *Om tecili.* Qy. Ometochtli (two rabbits), the god of wine.

Omiticuil. Clavigero I, 245.

Ometeuctli and omicihuatl, god and goddess residing in heaven, propitious to mortals. Also known as *Citlallatonac* and *Citlalicue.*

[6] *Moyocoya*, or more properly *moyocoyatzin*, is the third person singular of the verb yocoya, to do, with the respectful or reverential termination tzin (A. H. M., 70), meaning "he who acts or does." Ramirez translates it as "the omnipotent" (*todo poderoso*); Brinton, the determined doer. The title is given him in reference to his demiurgic power.

[7] Evidently an error for the terrible war-god, Huitzilopochtli. (Boturini 27; Herrera III, III, 17, *Vitzilipuztli.* Lorenzana, I. Huitzilo-potzli.)

In the sixteenth century it was customary to express the same sound indiscriminately by *Vi* and *Hui.* (Orozco y Férra. Anales II, I, 71.)

Garcia (IV, 300) Huitzilopuctli answers to Mars. In this author the name occurs most frequently as Vitzilipuctli.

Vchilobos. Clavigero (Cullen I, 254). Huitzilin, a humming bird. *Opochtli*, left. Boturini wrong. The Spaniards, unable to pronounce the name, usually called him Huichilobos. Orozco y Berra (Anales II, I, p. 71), thinks that of all the forms *Vitziliuil* is the most correct.

[8] (Çipactonal, Boturini 46, the father superior to the son.) Çipastonal and Uxumuco, more properly *Çipactonal* and *Ozomuco.* (Oxomozco, *Boturini*, p. 46), whose names have not been as yet satisfactorily explained. "*Tonal* is no doubt from *tena* to shine, and *cipactli* * * * from *chipauac*, beautiful or clear. (A. H. M., 74. Vide Chavero, Anales, II, 116.)

[9] Maize. Maize was the emblem of *Centeotl*, goddess of cereals, who was the same as *Xilomen* (from *Xilotl*, a young grain of maize). She was also the same as *Tzazolteotl*, the Venus vaga, goddess of impure love. L'Ecriture hieratique Maya par Leon de Rosny, p. 185.

[10] Tialocatecli. *Tialoc* was, according to Boturini (p. 72), the second deity and quasi minister of the Divine Providence. Brinton (A. H. M., 75, 121) considers him as the god of darkness; his name being, according to some, wine of the earth. Tial (*tlalli*, earth) oc (*ocqui*), wine of the maguey plant; according to others, dweller on earth, *tlalli* (the earth) and *onac* (being).

The name according to Brinton (A. H. M., 123) should be Tialoctecutli, lord of the wine of the earth.

Garcia (IV, II, 130, ch. vii) Tialocatecutli is the god of water; Tialoc (IV, VIII, 11, 143).

Clavigero I, 251. Tialoc, god of water; he resided on the highest mountains where the clouds are formed

[11] Chalchiuhcueiti (Boturini 25). La della Saya de Piedras preciosas, hieroglyphic of water; is generally shown with reeds. Probably took her origin among canebrakes. Cf. Venus sprung from the Sea.

Chalchiuitlicue, Chalchihuitlicue, Brinton, (A. H. M., 123, p. 75). From Chalchihuitl, jade. Cueiti, skirt, petticoat. Cf. *Kilt.*

If Tialoc was the god of water and tropical rains, may not his wife have signified the verdant results from his beneficial showers.

Chalchihuitlicue. Clavigero (tr. Cullen I, 240), goddess of water, 252. The high priest wore the same habit in which they represented her as the goddess of water. Cf. p. 252, for names given by Torquemada and Boturini.

Chalchihuitlique was the goddess of water and companion of Tialoc. Torquemada calls her *Xochiquetzal*, and Boturini, *Macuixochiquezalli* (Clavigero I, 252). According to the Codex *Telleriano-Remensis, Chalchiutli* saved herself from the

deluge. Her name signifies "The women adorned with a dress of precious stones. According to Sahagun she was the sister of the Tialocs, the rain gods (Codex Troano, 102).

Chalchiuhtteuh, *a modo de Esmeralda*. Sandoval, Gram. Mex., 53.

[12] *Alcançia*, literally, a money-jug of earthenware.

[13] *Hunchback*. It was the custom among the Aztec lords to have among their attendants for their diversion hunchbacks, just as the Mediæval barons had in their train their fools and jesters. The sacred cavern was that of *Cincalco*.

Quetzalcoatl was followed in his passage of the Sierra Nevada by hunchbacks, who mostly froze to death (A. H. M., 115). These formed part of the suite of the last Montezuma. They were interred with their Caciques. (Herrera ii, 165.) *Chalco*, seems to be derived from *Challi*, an emerald. Buschman, §89.

[14] Called Çipagli in preceding part of the chapter.

Çipactli (A. H. M., 74, 126), the great fish. Cf. the fish *Oannes* in the Chaldæan mythology, *Dagon* of the Philistines and Phœnicians, *Piscés* of the Syrian and Egyptian Zodiac; supposed to be sun myths, the sun rising out of the East.

Cipoconal and Oxomuco, the first created pair, qy. *pisces* of the Zodiac, &c. Note 9. Chavero (Anales I, VII, 245) considers Cipactli the first light below the horizon.

Jesus is represented as a fish, because the Messiah in the Talmud is called *Dag*, *i. e.*, the fish. King's Gnostic's and their remains, 138.

[15] Tlalteeli, the earth, from tlalli, the earth.

[16] The wife of this son was made of the hairs of the divine mother of the four brethren—gods, whose name was Xochiquetzal (Beautiful rose). (A. H. M., 73, 74.)

[17] Garcia (*Origin de los Indios*, V, IV, 327), gives a different account of the creation of which the following is a résumé:

"At the distance of a league and a half from *Guaxaca*, in an Indian settlement named *Cullapa*, there is a convent of my order whose Vicar, at the time of my coming there, owned a MSS. volume, * * * written in the figures used by the Mexicans, and with the explanations thereof, setting forth the origin and creation of the world, and the deluge, &c. This book I tried by all manner of means to obtain, but the holy father set too great a store on it to part with it, but permitted me to make such extracts from it as I desired.

"In the year and in the day of darkness and clouds, before there were any days or years, the world was plunged into total obscurity, and all was chaos and confusion; the earth was covered with the waters, and there was nothing but mud and débris over the face of the globe. In these days there appeared visible to sight a god whose name was the stag (*Ciervo*), and whose surname was Lion-viper (*Culebra de lion*), and a very charming and beautiful goddess, whose name was likewise *Ciervo*, and whose surname was Tiger viper (*Culebra de tigre*). From these divinities originated all the other gods of the Indians. As soon as these two gods appeared they took on human shape, and being omnipotent and omniscient, they founded a huge rock (*Peña*), on which they built sumptuous palaces, made with the greatest art, where was their home, and their abode on earth; and on the summit of the most lofty part of the palaces, there stood an axe of copper with its edge upwards, upon which the heavens rested. This rock and the palaces of the gods were on a very lofty mountain peak (*Cerro*) near the pueblo of Apoala, in the Province known as *Mixteca Alta*. This rock, in the language of that people, bore for its name *The-place-where-the-heaven-was*, by which they meant to express that it was the Paradise and abode of all manner of pleasure and happiness, and where there was an abundance of everything that was good, and where not the slightest element was ever lacking to complete felicity. This place was where the gods abode at their first coming on earth, where they remained many ages in quiet and contented rest, as the locality was so pleasant and charming, but the world was all in darkness and clouds. * * * Of these gods, the father and mother of

all the other divinities, in their palaces and court, were born two sons, very beautiful, shrewd and learned in all the arts and sciences. The first was called *The-wind-of-the-nine-vipers*, which he took from the name of the day on which he was born; the second received the appellation of the *Wind-of-the-nine-caverns*, that being likewise the name of the day on which his nativity occurred. These two youths were brought up in great pomp. The elder when he would amuse himself, took the form of an eagle and went flying through the highest skies, the second transformed himself into a tiny animal in the form of a winged snake, with which he flew through the air with so great a velocity and subtlety that he penetrated the hardest rocks, and became invisible. The effect of which was that those who were over his head could hear the noise and turmoil that was made below. The meaning of these figures was to exhibit the power that these gods possessed of transforming themselves and of their returning to their own shapes.

"These brothers then remained in their paternal home, living in comfort and peace; they bethought themselves that they would make an offering and sacrifice to the gods, their parents, to effect which they took censers of clay with burning embers upon which they cast a certain quantity of ground poison in lieu of incense. This, say the Indians, was the first offering ever made in the world. After they had made this oblation, the brothers created a pleasure garden for their recreation, in which they placed trees and flowers, fruits and roses, sweet-smelling plants and other varieties of vegetation. Here in this garden and orchard, they refreshed and recreated themselves all the time and they made near it another pleasure-ground (*Prado*), in which were stored all manner of things necessary for the oblations and sacrifices which they had to make and offer to the gods, their parents.

"Whenever these brothers left the house of their parents, they disported themselves in this garden, taking care of the trees and plants, and seeing to their increase and preservation, and offering from time to time the aforesaid oblation of poison, &c. They prayed to their parents at the same time, making vows and promises, and supplicating them by virtue of the oblation which they were offering, and through the other sacrifices they gave them, that they would think well of creating a heaven, and that they should shed a light upon the world, that they should create the earth, or rather let the waters sink and the dry ground appear, for that they had no other abode and resting place than the narrow limits of their garden and orchard. And still more to force the gods to accede to their request, the suppliants pierced their ears with lancets of flint, drawing blood from them in torrents. This they did also to their tongues, and with the blood they sprinkled the branches and trunks of the trees by means of a sprinkler made of the branches of the willow tree as a thing holy and blessed. This action they performed to show their entire submission to the will of their parents whom they regarded as being greater gods than themselves. * * * These gods had children * * * after which there was a general deluge in which many of the gods were drowned. When this had ceased, the creation of the heavens and the earth was begun by a god whom they name *Creator of all things*, who restored the human race, from which was populated the *Mixtec* kingdom."

[18] Of the Mexican Year.

Boturini 2.		*Gemelli* (Anales I, 7, 299).
1 Tecpatl,	(pebble)	1 Calli
2 Acatl,	(reed)	2 Acatl
3 Tochtli,	(rabbit)	3 Tecpatl
4 Calli,	(house)	4 Tochtli

Veytia agrees with Boturini, and Orozco y Berra (Anales 1, 7, 299), accepts their arrangement and nomenclature.

The eighteen months of the year are named as follows:

NAMES OF THE MONTHS.

(Lorenzana, 2.)		Orozco y Berra (Anales I, VII, 294).
1. Atemoztli	(water month)	1. Itzcalli, Xochilhuitl.
2. Titiil	(things even and just)	2. Xilomanalzitli, atlacahualco, Cuahuitlehua, Cihuailhuitl.
3. Yzcalli	(new creation)	3. Tlacaxipehnaliztli, cohuailhuitl.
4. Xilomanizte	(offerings of the new maize)	4. Tozoztontli.
5. Coanilhuitl	(grand festival of the viper)	5. Hueytozoztli.
6. Tozcotzintli	(lesser fast)	6. Toxcatl,Tepepochuiliztli.
7. Huey Tozcoztli	(greater fast)	7. Etzalcua liztli
8. Toxcatl	(dangerous for the fields)	8. Tecuil Nuitzintli.
9. Ezalqualliztle	(eating of dry fruits)	9. Huey tecnilhuatl.
10. Tecuilhuitzintli	(feast of the youthful cavaliers)	10. Micailhuitzuitli, Tiarochimaco.
11. Huey Tecuithuitl	(feast of elder lords)	11. Huey micail huitl, Xocotlhuetzi.
12. Micta ilhutzintili	(lesser feast of the dead)	12. Ochpaniztli, Tenahuatiiztli.
13. Huey mictail huit	(greater feast of the dead)	13. Pachtli, Teotleco.
14. Ochpanitzli	(broom)	14. Hueypachtli,Tepeilhuitl.
15. Pachtlizintli	(early grains)	15. Quecholli.
16. Hueypachtli	(grains and large trees)	16. Panquetzaliztli.
17. Quecholli	(the flamingo?)	17. Atemoztli.
18. Panquetzallitzli	(pennons or banners)	18. Titiil.

DAYS OF THE MONTHS.

Lorenzana (2)	Chavero (Anales I, VII, 245).
Cipactli (serpent)	1. Cipactli (the first light from below the horizon)
Ehecatl (air)	2. Ehecatl (the wind)
Calli (house)	3. Calli
Cueztpallin (lizard)	4. Cuetzpalin
Cohuatl (viper)	5. Cohuatl
Miquitzli (death)	6. Miquitzli
Mazatl (deer)	7. Mazatl
Tochtli (rabbit)	8. Tochtli
Atl (water)	9. Atl
Ytzcuintli (a common dog)	10. Itzcuintli
Ozmatli (a she ape)	11. Ozomatli
Malinalli (a mesh of cords)	12. Malinalli
Acatl (reed)	13. 1. Acatl
Then follows the second group:	
Ocelotl (tiger)	14. 2. Ocelotl
Quaotli (eagle)	15. 3. Cuauhtli
Temtiatl (grindstone)	16. 4. Cozcacuauhtli
Quiahuitl (rainy water)	17. 5. Ollin.
Xochitl (flower)	18. 6. Tecpatl
	19 7. Quiahuitl
	20. 8. Xochitl

[19] *Cintrococopi*, qy. from *cintli*, spindles (Mazorcas), full of dry and cured maize and *cocopatic*, something that burns the mouth greatly. (*Molina* sub vocibus.)

[20] The story of the falling down of the heavens appears among the myths of Samoa, where two trees are reported to have grown up and pushed them into proper place. The natives of *Vaitupu* have a tradition in which two of the sons of the first couple "distinguished themselves by raising the heaven higher." In *Nikundu*, the legend runs of an universal darkness in the beginning of all things and that the heavens were down and resting upon the earth until raised by two brothers. (Samoa, by George Turner, pp. 198, 283, 291.)

[21] The two trees into which the gods changed themselves; more properly, Tezcaquahuitl, the tree of the warrior. Quetzalveixochitl, the beautiful rose tree. —A. H. M., 75.

[22] Mixcoatl, a name of Tezcatlipoca. Brinton, A. H. M., 84. Iztac Mixcoatl (A. H. M. 92), white-cloud, twin.

[23] Four hundred men created. Brinton considers them to be the stars, especially as they later were translated to the sky. Codex Chimalpopoca (Myths, New World, 207). Four birds devoured the antediluvian dwellers on earth.

[24] They drew blood from their ears, &c. In ch. 8 (seq.) Camaxtli takes a maguey thorn and draws blood from his tongue and ears. The Persians drew blood from ears, arms and face. Cf. *Garcia*, Iv, 301.

[25] *Tulocatecli* threw his son into the cinders. Should be *Tlaloc*. (Cf. Abraham and Isaac.)

[26] Chichimecas (Garcia, V, 2, 322), offered no let or hindrance to the immigrants who drove them away, but were filled with fright and astonishment, and hid themselves among the most inaccessible rocks.

But the C. on the other side of the Sierra Nevada, where the Tlascaltecans came, did not behave in this manner, but valiantly resisted the invaders, being of gigantic stature, endeavored to drive them out of the land, but were ultimately overcome by the force of the Tlascaltecans. Then they had resort to stratagem, and feigning peace and submission invited their conquerors to a banquet at which concealed men precipitated themselves upon the Tlascaltecans when they had become drunken and helpless. However, the Tlascaltecans rallied to the assistance of their comrades, and being better armed and disciplined, ultimately defeated the giants, leaving not one man alive. After many generations the barbarous Chichimecas became civilized, wore clothes and became as other people, forming themselves a state. (Cf. Garcia, V, 302.)

Chichimeca. (Clavigero tr. Cullen, I, 91), according to some from *Techichiani*, sucking, because they sucked the blood of the animals which they hunted. C. calls them *Checchemecatl*, (Betancourt), from Chichimi, dogs' beans. If the name had been one of contempt they would not have prided themselves upon it, as they did. Another point to show it was an indigenous word.

A number of conjectural etymologies have been assigned for this name, but all unsatisfactory. As this people appear to have been aboriginal it seems to me that any attempt to explain its name by means of the language of the conquerors must be futile. Those who speak an alien tongue have always been looked upon by their neighbors as barbarians, and even as not possessed of rational speech, but as using only an unintelligible jargon. The Latin dramatist expresses the feeling in his lines, *Barbarus hic ego, quia non intelligor nulli.*

a/

According to Garcia (V, 3, 321), the word Nahuatl means the people that speaks distinctly and makes itself understood (Cf. Sahagun X, 29.) (Buschman, 685), "well sounding, clear, distinct."

Boturini, 78. Chichimècatl, el que' chupa, from their sucking the blood of animals. *Chichi* means mamar, to nurse. Anales 3, 2, 60.

[27] *Camasale*, more properly, *Camaxtli*, qu., a name of Tezcatlipoca (A. H. M., 90); *la faja noturna* (Anales 3, 363). He was worshiped by the Tlascallans, being there the same as Huitzilopochtli. Clavigero I, 2, 111. (Cf. Note 3.)

[28] Ce acatl, *one reed*, the day of Quetzalcoatl's birth, and by which he was often called. It was a day of evil omen, and no one born on it could hope for success. This year which returns but once in the Mexican cycle of fifty-two years, was

ERRATUM.

On page 648, 12th line from bottom, for *quid non intelligor* read *quia non intelligor*

the one in which the god Quetzalcoatl was expected to reappear; and it so happened that in this very year Cortez entered the land of Mexico. Gloomy prophecies had preceded his advent, and he met a sovereign predisposed to submission.

[29] Tlapalla. This is the *Tlapallan* which Brinton (A. H. M., 89) believes to be the "City of the Sun," the original home of the Aztecs. All this he considers a sun myth. The word signifies "the red land" (Codex Mendoza, Anales I, 4, 178). It was to this country that Quetzalcoatl was to take his journey (Buschman, p. 684).

"*Tlapallan*, the red land, and *Tizapan*, the white land, were really the names for the land of the sun. Tizapan from *tizatl*, white earth, and *pan* in." (Am. Hero Myths, 135.) The idea holds ground among some scholars that this long record is only one of journeyings up and down through the valley of Mexico.

[30] Chapultepeque. Monte des Conejos. (Garcia, IV, 283.) Cerro del Chapulin (Bot. 78). See note 43.

[31] Culuacan. Colhuacan (A. H. M., 92). The bent or curved mountain, the home of the mother of the gods; on it the old become young and remain at any age they desire; years leave no trace upon them. In the legends of the Choctaws occurs mention of a *bending hill* (Myths New World, 225). Duran (I, 1) considers it another name for Aztlan. Cf. Buschman, 691.

[32] *Azclan*, regio de garças, land of the heron. (Garcia, 4, 293.) Bright or white land. (Brinton A. H. M., 92. Buschman, 612.) The latter the more generally received; cf. *Tlapallan*, Note 29.

[33] *Suchimilco*, first people (gente de sementeras de Flores), occupied the banks of the great lagoon of Mexico and founded a city of the same name. Garcia, V, § 2, 322.

[34] *Xochimilco*. Place of the field of flowers. (Buschmann, p. 700; Clavigero, 2, 228; Boturini, 78.) Sometimes written *Suchimilco*.

[35] *Mixcoatl* (Brinton A. H. M., 92, Iztac-Mixcoatl, the white cloud twin), goddess of hunting, *Clav.*, i. 126. Same as Camasale (Notes 3, 27).

[36] *Chalcas*. The name signifies *Gente de las Bocas*. Garcia, V, 2, 322.

[37] *Tenpaneca* (*Garcia*, V, 2, 322). Gente de la puente, settled on the west side of the lagoon. They soon founded a large city, Azcapuzalco (Hormiguero).

[38] *Tezcuco*. Garcia (V, 2, 322) says the Tezcucans were the fourth population of Mexico, coming from *Culua* (*Gente corva*), because in their country there was a very crooked *Cerro*.

These four nations encircled the lagoon, and of them all, the Tezcucans were considered as the most polished.

[39] Quausticaca? *lugar de los Pinos*.

[40] Chicomuxtoque, more properly should be *Chicomoztoc*, the Seven caverns. (Garcia, V, 325: Boturini, 78. Buschmann, über die Aztek. Ortsnamen, 688.)

[40] Coatebeque, more properly *Coatepec*, the hill of serpents.

[41] *Quatlique*, more properly *Coatlicue*, "one of the serpent skirt" (A.H. M., 77) from whom Huitzilopochtli was born. According to Clavigero (1257), she was the goddess of flowers.

A similar myth is narrated (A. H. M., 90) of the birth of Quetzalcoatl, "the feathered serpent," which seems more probable from the connection of this name with the bunch of feathers, the virgin is stated here to have placed in her bosom.

[42] *Cuzco* means (Garcia, IV, 293) the navel of the earth.

[43] *Bridge* of Chapultepeque: this is probably a clerical error of *puente* for *fuen'e*, as in the preceding chapter a (fountain or) stream of water (fuente) is spoken of as existing at that place. The word means hill of the locust, from *chapulin*, locust, and *tepec*, a hill. (Cf. Note 30.)

[44] In the original *tes*, meaning evidently *tres*.

[45] In the original *dos*, probably an error for *los*.

[46] Çiquacoatl, more properly Cihuacoatl; the serpent woman (Myths New World, 120); Cihuacohuatl (Clavigero, I, 216).

[47] Tiçapan } the same place. (Garcia, 326, *Tizaapán*, aguas blancas, white
Tiçapaa } water). The general view entertained by scholars is that the word means the white land (A. H. M., 135), and is the same as Tlapallan, the home in the distant sun. See note 29.

[47*] Here there is something omitted, probably the words "a woman," as the rest of the sentence requires it.

Clavigero (Book II, § 21, Cullen, p. 124, tells a horrible story of a woman's sacrifice (too long to copy), which may be the one here referred to.

[48] Quanmixtitlan, *postea* Tenustitan. Garcia, 325; Cuidad del popul, Bot., 78. Tenoxtitlan, more correctly Tenochtitlan, from *tetl*, a stone, and *Nochtli*, a nopal (meaning the wild fig on the rock. *Tunal en piedra*, Garcia, V, 326). Buschmann, p. 702.

[49] Acamapictli. Garcia, V, § 3, 334. Third king of the Mexicans, *Coringio*, being second, and *Tenuch* first. (*Clavigero*, I, III, 127; Lorenzana, p. 9.)

Names of the kings of Tenochtitlan according to

Clavigero, I, III, 127.	*Lorenzana*, 9.
1. Acamapitzin	1. Acamapixtli
2. Huitzilihuitl	2. Huitztlihuil
3. Chimalpopoca	3. Chimalpopoca
4. Itzcoatl	4. Ixcoatl
5. Monteuczoma or Montezuma	5. Montezuma, the elder
6. Axajacatl	6. Tizotzin
7. Tizoc	7. Axaiacac
8. Ahuitzotl	8. Ahuitzol
9. Montezuma	9. Montezuma

Anales II, 1, 53.

1. Tenuch, A.D. 1324.
2. Acampichi, A.D. 1370.
3. Huicilyhuitl, A.D. 1396.
4. Chimalpupuca, A.D. 1417.
5. Ixcoaci, A.D. 1427.
6. Huehue motecçuma, A.D. 1440.
7. Axayacaci, A.D. 1469.
8. Tiçocicatzi, A.D. 1482.
9. Ahuiçocin, A.D. 1486.
10. Motecçuma, A.D. 1502.

Garcia (V, *iii*, 324), makes Acamapictli the third ruler.

[50] Seems to resemble the title of Prince Consort.

[51] *Cuernavaca*. Garcia (Origin de los Indios, Lib. V, § II, p. 322) says that *Quauhnahuac* (a word meaning the place whence the voice of the eagle sounds) was corrupted in common language into *Cuernavaca*. He states that it was the capital city of a fertile and populous province, which, in his days, was known.

[52] They took away. (Qy. the original one?)

[52*] Tlascaltecas (gente de pan). Garcia, V, 1, 322. Were the sixth people; built and settled, and their chief city was named Tlascala. This nation aided the Spaniards.

[53] Dende un año *ynvernan?*

[54] The Indian woman, *Marina*, who fell in love with *Cortez*, and accompanied him as his interpreter. The words in the original are, "Por una lengua dicha *Marina*."

[55] Sahagun, Lib. XII, ch. 29, also speaks of this epidemic of small-pox.

[56] *Oydores*, auditors, councillors of state.

[57] *I.e.*, the days to lengthen.

[58] Tçauçigua (fleshless women), alias Çiçemine. More properly, Tzitzimimine (Anales II, i, 7), the dreadful ones. The conclusion of a cycle was a grave event for the Mexicans, for, according to their religious ideas, it was possibly the date for the end of the world. "All the inhabitants," says Torquemada, "were in great fear and trembling lest when the lights were extinguished they should never more be rekindled, but on that very night the human race would come to an end, and darkness eternal would reign over all; no sun should ever appear again, but the *Tzitzimimes*, fearful demons, would descend and eat up all mankind." *Anales, &c*, II, i, 7.

[59] I. *Se echaron una con otra.*

[59a] Quey, ver, omitted? In which case the sentence read *Este no pudo* (*ver*), *á Montezuma*, could not bear with Montezuma, detested him.

[60] How much more humane than the maxim of the civil law, *partus sequitur ventrem!* One who lay with an immature girl, or another's slave, became a slave. (Garcia, 3, 2, III: Torquemada, XII, 8; Herrera, IV, 8, 10)

[61a] Tianguez should be more properly Tianquitzli. (Anales III, 2, 66.)

[62] *Papa*. "The Mexicans called in their tongue the Supreme Pontiffs by the name of *Papa*." (Herrera III, II, *xv*, p. 690. *Similiter*, Garcia V, XII, 300.)

Papachtic. "He of the flowing locks," corrupted to Papa, was one of the names of Quetzalcoatl (A. H. M., 69), hence the title may easily have been transferred to his priests.

The Pennsylvania Prison System. By Richard Vaux.

(Read before the American Philosophical Society, June 20, 1884.)

The Pennsylvania Prison System had its origin in an effort to correct the abuses in the place of incarceration of all classes of violators of law. The common jail, under the colonial government of the Province of Pennsylvania, was the receptacle of every such offender.

In the city prison of Philadelphia, located at Market and Third streets, in 1770, young and old, black and white, men and women, boys and girls were congregated indiscriminately in custody, for misconduct, misdemeanor, and felony, either before trial, after conviction, or for want of bail for surety of the peace. It was a moral pest-house. Bad as it was, it was better than Newgate, for England was without a rival in the infamous management of her then chief public prison in London.

So early as 1775 a sensible, thoughtful man—a merchant—Mr. Richard Wistar, residing near by, had his attention directed to the horrible condition of this city prison. In 1776, on the 7th of February, a society was formed, styled the "Philadelphia Society for Assisting Distressed Prisoners." The occupation of Philadelphia by the British army terminated the labors of this society in the month of September, 1777. In the year 1787, May 8th, the first society was revived by its successor "The Philadelphia Society for Alleviating the Misery of Public Prisons." Some of the members of the first Society, and others like-minded, engaged in this revival of the organization of 1776.

On the 16th of August, 1787, William White, D.D., Bishop of the Prot-

estant Episcopal Church, as president of this society, addressed the citizens of Philadelphia for aid—aid for a practical benevolence which found the evil, and undertook to apply the remedy. It was not humanitarianism—that restless agitation of the sympathies of try-to do-something people, which usually is converted into mist.

The criminal laws from 1718 to 1794 were ameliorated. In 1718 ten crimes were capital. On the 15th of September, 1786, by the influence of an already developed interest, an act of Assembly was passed to markedly modify the criminal code of the province. This was the first legislative reform. It substituted for robbery, burglary, and the crimes against nature, imprisonment at hard labor, for the death penalty. On the 27th of March, 1789, this first act was amended. The act of April 5th, 1790, repealed both acts, and the act of 1794 made murder only, a capital crime. No important legislation, as to the criminal code, occurred from 1821 to 1860.

The first Constitution of the State in 1776, chapter 2, section 28, provided "That punishments be made in some cases less sanguinary;" and by section 39, hard labor in prisons be substituted. In 1786 some of these provisions were enforced. "Penn's Great Law" of 1682, enacted for his province, 10th section, provided that "all prisons shall be workshops for felons, vagrants, and loose and idle persons." Prior to the Revolution these laws were generally disregarded.

From Mr. Richard Wistar's first efforts in 1775, till April 5th, 1794, slow but effective measures were taken to reform the penal laws and the prison system of Pennsylvania. They were the outcome of the earliest practical thoughts on this subject in America.

It is to be noticed that in Italy, 1718, the Hospital of St. Michael was founded, and there was first introduced in Europe reforms in prison discipline. It was an experiment suggested by philosophy and benevolence, and remained for nearly a century the only like instance on that continent.

It was a successful undertaking. Parenthetically it may be said, without too broad an assertion that, so far as is known, the present congregate prisons of the United States in some features are copies of the St. Michael, originated one hundred and sixty-six years ago.

In 1718, February 22d, a law was passed for erecting houses of correction and work-houses in the Province of Pennsylvania. While this law of 1718 authorized these establishments, they were intended simply as receptacles for vagrants and incapables.

In 1775 a work appeared on "The State of Prisons in England and Wales," which first directed the attention of the English people to the subject of the then terrible condition of these institutions.

During this progress of a thoughtful investigation into the needed reform of existing methods of prison management, it became apparent to those in Philadelphia engaged in the examination, that a radical change in both the crime code, and the punishment of convicts was the only possible relief for the abuses and miseries existing in the prisons. The crime code was

severe without discrimination, the prison treatment of convicts was irrational, disgraceful, and produced those results both were intended to prevent.

The evil was at the root of convict treatment, at the foundation on which the plan rested. Incarceration at hard labor was the only specific for all felonies or crimes of aggravation.

The public mind considered public safety secured if violators of law were imprisoned, and there it ceased to regard the crime or the criminal.

This actual condition of the law and its administration convinced the able men interesting themselves in the question, that in the incarceration of criminals a thorough change of method must be established by law.

The associating or congregating convicts at work or otherwise while in prison was deemed so unwise, degrading, and irrational, if any benefit to the prisoner or advantage to society was expected from imprisonment, that this form of treatment must primarily be abolished. This was the initial step in prison reform. The leading minds investigating this subject reached this conclusion so early as 1787.

A memorial from the Society for Alleviating the Miseries of Public Prisons was addressed to the representatives of the freemen of the Commonwealth of Pennsylvania in General Assembly met, on the shocking treatment of prisoners then existing, in which it is stated "that punishment by more private or even solitary labor would more successfully tend to redeem the unhappy objects." The memorialist recommended for the consideration of the General Assembly "the very great importance of a separation of the sexes in public prisons." Legislation to this end was asked. In this memorial is to be found the first suggestion of two principles, which either in their assertion or presentation, gave no promise of the signal importance they were to exercise over the subject of prison reform, or that they were to become the basis of the Pennsylvania prison system. They were the origin of the system of separation of prisoners during their incarceration, and that labor was an element in their punishment.

To this memorial the Supreme Executive Council of Pennsylvania, on the 20th of November, 1788, replied by the adoption of a resolution asking information as to its subject-matter.

The society made a full statement to this resolution of inquiry, and it was presented to the Council in 1788.

In the following year the society presented a plan for the positive improvement of the prison discipline of the State.

The propositions contained in this plan were enacted into the law of 1790.

In 1773 the erection of a State prison was begun, located at the southeast corner of Sixth and Walnut streets, in Philadelphia, and on its completion the test was applied of the reforms suggested.

The Legislature, by the act of April 8th, 1790, to reform the penal laws of this State and try the separate confinement principle of imprisonment, declared its purpose in this act as follows: * * *

"And whereas, the laws heretofore made for the purpose of carrying the said provisions of the Constitution into effect have in some degree failed of success, from the exposure of the offenders employed at hard labor to public view, and from the communication with each other not being sufficiently restrained within the places of confinement; and it is hoped that the addition of unremitted solitude to laborious employment, as far as it can be effected, will contribute as much to reform as to deter.

"Section 8 of the act provides for the erection of cells in the gaol yard for the purpose of confining there the more hardened and atrocious offenders. Section 10 declares the cells to be a part of the gaol and requires all persons who cannot be accommodated in the cells to be kept separate and apart from each other, as much as the convenience of the building will admit.

"Section 18 restricts the visitors to the prison to various officials and persons having a written 'license' signed by two inspectors."

This law was a decided triumph for those engaged in prison reforms. It was the first authoritative endorsement by the Legislature of Pennsylvania of the two principles to which attention has been called. Though tentative in its object, it placed the Pennsylvania prison system on its trial, limited as it was to the most ill-devised and circumscribed opportunities.

In the year 1801 the society again addressed the Legislature stating the progress made by former Legislatures in preventing crime and reforming criminals were satisfactory, * * * "though it was not expected that the practical part could be suddenly or completely effected." It was considered then only as an experiment. The society again urged the Legislature to make a fair experiment of solitude and labor on convicts.

In 1803 a marked confidence is shown by the memorial of the society to the Legislature, as the following extract proves:

"Placed as we are in a situation to observe the salutary effects of solitude and labor in preventing crimes and reforming criminals, we trust you will as heretofore receive our application with indulgence, and therefore again respectfully submit to your consideration the propriety of granting another building for the purpose of making such separation amongst prisoners as the nature and wants of this truly benevolent system requires."

Persistent in its efforts, and gaining knowledge and faith from experience, in 1818 the society more broadly expressed itself in a memorial to the Legislature. Confirming the satisfaction which thus far had attended the trial of the system, imperfect as it was, the memorialist * * "therefore respectfully request the Legislature to consider the propriety and expediency of erecting penitentiaries in suitable parts of the State for the more effectual employment and separation of prisoners, and of proving the efficacy of solitude on the morals of those unhappy objects."

After such earnest appeals, asserting the confident belief in the principles of separation of convicts during imprisonment by men whose high

character and large ability gave great weight to their opinion, the Legislature could not fail favorably to regard the prayers of the society.

But it was not till 1821, that, after the last effort of the society to obtain the necessary and essential legislation, the law was passed on March 20, 1821, for the erection of a State Penitentiary within the city and county of Philadelphia.

Justice, simple justice, to the labors which resulted in the enactment of this law, and the men who secured its passage, makes it proper to give this memorial of the society on which the Legislature was induced to act. It is a statement, or the epitome of the reform, for the half century preceding its publication:

To the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met:

The memorial of the Philadelphia Society for Alleviating the Miseries of Public Prisons, respectfully represents:

That it is now nearly forty years since some of your memorialists associated for the purpose of alleviating the miseries of public prisons, as well as for procuring the melioration of the penal code of Pennsylvania, as far as these effects might be produced through their influence.

In performance of these duties which they believed to be required of them by the dictates of Christian benevolence and the obligations of humanity, they investigated the conduct and regulations of the jail, and likewise the effects of those degrading and sanguinary punishments which were at that period inflicted by the laws of this Commonwealth. The result of these examinations was a full conviction that not only the police of the prison was faulty, but the penalties of the law were such as to frustrate the great ends of punishment by rendering offenders inimical, instead of restoring them to usefulness in society.

With these impressions, alterations in the modes of punishment and improvements in prison discipline were from time to time recommended to the Legislature, by whose authority many changes were adopted, and many defects remedied.

These reforms, from the nature of existing circumstances, were, however, of comparatively limited extent, but as far as the trial could be made, beneficial consequences were experienced.

Neighboring States and remote nations directed their attention to these efforts, and, in many instances, adopted the principle which had influenced the conduct of Pennsylvania.

At the time of making the change in our penal code, substituting solitude and hard labor for sanguinary punishments, the experiment was begun in the county jail of Philadelphia, rather than the execution of the laws should be deferred to a distant period, when a suitable prison might be erected. Under all the inconveniences then subsisting, the effects produced were such as to warrant a belief that the plan would answer the most sanguine wishes of its friends, if it could be properly tried. But

the construction of that prison and its crowded condition, being the only penitentiary used for all the convicts of the State, leave but slender hopes of the accomplishment of the humane intentions of the Legislature.

Your memorialists believe that they discover in the recent measures of the Commonwealth, a promise which will fulfill the designs of benevolence in this respect. The edifice now in progress at Pittsburg for the reception of prisoners, constructed upon a plan adapted to strict solitary confinement, will go far towards accomplishing this great purpose; and your memorialists are induced to hope that the same enlightened policy which dictated the erection of a State prison in the western, will provide for the establishment of a similar one in the eastern part of the State.

Reasons of the most serious and substantial nature might be urged to show the absolute necessity which exists for a penitentiary in the city and county of Philadelphia, whether we regard the security of society or the restoration of the offenders against its laws. It will not be necessary here to recite the alarming proofs which might be adduced in support of their opinions, but refer to the documents herewith furnished, which exhibit the actual condition of the prison. Your memorialists, therefore, respectfully request that you will be pleased to take the subject under your serious consideration, and if you judge it right, to pass a law for the erection of a penitentiary for the Eastern District of the State, in which the benefits of solitude and hard labor may be fairly and effectually proved.

Signed by order and on behalf of the Society.

WILLIAM WHITE, *President.*
WILLIAM ROGERS, *Vice-President.*
THOMAS WISTAR, *Vice-President.*

NICHOLAS COLLIN,
SAMUEL POWEL GRIFFITHS,
JOSEPH REED,
ROBERTS VAUX.

Attest: CALEB CRESSON, *Secretary.*

This agitation of the reform in both the penal laws and system of convict punishment, though originating and developed in Philadelphia, extended to the western part of the State. On the 3d of March, 1818, the Legislature authorized the erection in the county of Allegheny, of a State penitentiary on the "solitary" plan, and in 1820 it was in the course of completion.

The non-association of prisoners being the primary object of the friends of the movement at its inception, and the congregation of all ages, sexes, and degrees of criminality being the gross evil sought to be abolished, it was necessary to suggest a method of incarceration which was in radical antagonism to the existing abuse. More intent in the trial of the proposition than in designating it by any special term, the word *solitary* seemed almost unconsciously to assert itself as the descriptive name of the reformed system. It was not in any sense the technical definition, and it

in some degree eliminated the idea of solitary, as contradistinguished to the associate or congregate relations of all prisoners in the county prisons or jails.

The use of this term "solitary" was most unfortunate in the first days of the trial of the new theory. Very much of the opposition that arose against it came from the misconception of the subject by the use of this word.

The Allegheny prison was designed by Mr. Haviland, an architect of Philadelphia, of very high professional repute. As there was no example on which to rely for the plan of the building intended for the complete and unexceptional *separation of convicts during imprisonment*, Mr. Haviland had to conceive the plan of the building from the information he could obtain from its advocates, and those few who were enlisted as its promoters.

The drawings for the Pittsburg prison, as it was called, were from the first impressions of what was necessary.

In 1821, when the Eastern or Philadelphia State Penitentiary was erected, Mr. Haviland's experience suggested many improvements, so that the Eastern Penitentiary, in 1829, when it was opened for the reception of convicts, was of course regarded as the true exposition of the *separate*, called however the *solitary*, system.

An examination of the corridors first erected prior to 1829, and those erected in 1872, will give the best idea of the improvements which experience made manifestly necessary.

Naturally so radical a change in the criminal law, act April 23d, 1829, and the mode of convict punishment, act March 20th, 1821, and the act of 28th March, 1831, as followed the partial completion of the *solitary* prison, and the enactment of these laws relating to crimes and penalties, caused discussion, hostilities, and opposition.

Better to condense the arguments of the friends and opponents of the Pennsylvania prison system, as it was then styled, the following extracts are given from then accepted authority:

Roberts Vaux, in his reply, 1827, to Mr. William Roscoe, of London, thus answers his chief objections:

"It is very evident to my mind that the true nature of the separate confinement which is proposed, requires explanation. I will, therefore, endeavor to describe what is intended by its friends. Previously, however, it ought to be understood that the chambers and yards provided for the prisoners are like anything but those dreary and fearful abodes which the pamphlet before me would represent them to be, 'destined to contain an epitome and concentration of all human misery, of which the Bastile of France and the Inquisition of Spain were only prototypes and humble models.' The rooms of the new penitentiary at Philadelphia are fireproof, of comfortable dimensions, with convenient courts to each, built on the surface of the ground—judiciously lighted from the roof—well-venti-

lated and warmed, and ingeniously provided with means for affording a continual supply of excellent water, to insure the most perfect cleanliness of every prisoner and his apartment.* They are, moreover, so arranged as to be inspected and protected without a military guard, usually though unnecessarily employed in establishments of this kind in most other States.

"In these chambers no individual, however humble or elevated, can be confined, so long as the public liberty can endure, but upon conviction of a known and well-defined offence, by a verdict of a jury of the country, and under the sentence of a court for a specific time. The terms of imprisonment it is believed can be apportioned to the nature of every crime with considerable accuracy, and will no doubt be measured in that merciful degree which has formerly characterized the modern penal legislation of Pennsylvania. Where, then, allow me to inquire, is there in this system the least resemblance to that dreadful receptacle constructed in Paris during the reign of Charles the Fifth, and which at different periods, through four centuries and a half, was an engine of oppression and torture to thousands of innocent persons; or by what detortion can it be compared to the inquisitorial courts and prisons that were instituted in Italy, Portugal and Spain, between the years 1251 and 1537?

"With such accommodations as I have mentioned, and with the moderate duration of imprisonment contemplated on the Pennsylvania plan, I cannot admit the possibility of the consequences which thy pamphlet predicts, 'that a great number of individuals will probably be put to death by the superinduction of diseases inseparable from such mode of treatment.' I do not apprehend either the physical maladies so vividly portrayed, or the mental sufferings which, with equal confidence it is promised, shall 'cause the mind to rush back upon itself and drive reason from her seat.' On the contrary, it is my belief that less bodily indisposition, and less mortality, will attend separate confinement than imprisonment upon the present method, for which some reasons might be given that would be improper here to expose.

"By separate confinement, therefore, it is intended to punish those who will not control their wicked passions and propensities, thereby violating divine and human laws; and, moreover, to effect this punishment, without terminating the life of the culprit in the midst of his wickedness, or making a mockery of justice by forming such into communities of hardened and corrupting transgressors, who enjoy each other's society, and contemn the very power which thus vainly seeks their restoration and idly calculates to afford security to the State from their outrages in the future.

"In separate confinement every prisoner is placed beyond the possibility of being made more corrupt by his imprisonment, since the least associa-

* The exact size of the chambers is eight feet by twelve feet, the highest point of the ceiling sixteen feet. The yards are eight feet by twenty feet.

tion of convicts with each other must inevitably yield pernicious consequences in a greater or less degree.

"In separate confinement the prisoners will not know who are undergoing punishment at the same time with themselves, and thus will be afforded one of the greatest protections to such as may happily be enabled to form resolutions to behave well when they are discharged, and be better qualified to do so; because plans of villainy are often formed in jail which the authors carry into operation when at large, not unfrequently engaging the aid of their companions, who are thereby induced to commit new and more heinous offences, and come back to prison under the heaviest sentences of the law.

"In separate confinement it is especially intended to furnish the criminal with every opportunity which Christian duty enjoins for promoting his restoration to the path of virtue, because seclusion is believed to be an essential ingredient in moral treatment, and, with religious instruction and advice superadded, is calculated to achieve more than has ever yet been done, for the miserable tenants of our penitentiaries.

"In separate confinement a specific graduation of punishment can be obtained, as surely and with as much facility as by any other system. Some prisoners may labor, some may be kept without labor; some may have the privilege of books, others may be deprived of it; some may experience total seclusion, others may enjoy such intercourse as shall comport with an entire separation of prisoners.

"In separate confinement the same variety of discipline for offences committed after convicts are introduced into prison which any other mode affords can be obtained, though irregularities must necessarily be less frequent, by denying the refractory individual the benefit of his yard, by taking from him his books or labor, and, lastly, in extreme cases, by diminishing his diet to the lowest rate. By the last means the most fierce, hardened, and desperate offender can be subdued."

The attention of leading minds in Europe was directed to these experiments in Pennsylvania.

England sent, in 1834, Mr. Crawford, a commissioner, to examine the Eastern State Penitentiary. They were followed by Mr. Beaumont and Mr. DeTocqueville, from France, and by Dr. Julius, from Prussia. The investigations made by these very able men were so satisfactory that in those countries reforms were adopted which largely partook of the principles incorporated in the Pennsylvania prison system.

From the date of the opening of the Eastern State Penitentiary for the reception of convicts (1829) until 1845. the subject of the adaptation of the system to its design received the careful attention of those so earnestly devoted to the success of the experiment. There has been no legislative change in the system as adopted in the Eastern State Penitentiary since the act establishing it, 1821.

It would burden this paper to give the results reached as they were

developed. The criticisms which were made by those who doubted its practicability, who opposed its principle, who believed it would be injurious in its effects on those subjected to its operation, and who feared the cost would not pay for its benefits, were continued, and, strange it is to say, yet continue, though the experience of half a century refutes them.

The philosophy of "separate or individual treatment" of prisoners during incarceration is the basis on which this system rests.

The originators and early advocators of a method of convict punishment, which as they then knew was only to be the non-association of all criminals in a common jail, were content if this reform could be secured. Such a plan having been adopted and put in operation, the principle of the experiment of constant separation of individual convicts in prison became the subject of careful study.

The objections were magnified as it became apparent that the idea of making profit out of the associate labor of prisoners was, though a superficial, a popular view, addressed to both the prejudices and the susceptibilities of the tax-payer. In every other State then, but Pennsylvania, the congregate system was accepted because it was claimed that these prisons could be self-supporting. This delusion is now being dispelled. Yet these self-supporting prisons demanded the public favor, and to secure this result prisoners were sold to contractors, who paid a fixed sum per diem for their toil, and made from their associate work in shops, large profits for these employers. So great a stimulus to the greed of those interested, and the indifference of the public, at last resulted in changing the Pittsburg Penitentiary from the separate into a congregate prison.

It was left to the Eastern State Penitentiary to defend the separate method. The progress made in the adaptation of punishment to each individual case, as experience and careful study demonstrated was practically for the best interest of the prisoner and the community, became singularly satisfactory.

From 1845 to 1855 the advance in the development of the promised advantages to the convict and society of this reform in prison discipline, marked a new era in the history of convict punishment.

During this period the experience gained by the advocates of the separate system enabled the authorities of the Eastern Penitentiary to ascertain the improvements that were necessary both in the architecture of the building, and the method of administering the discipline.

The corridors and the cells as they then existed were found to be ill-suited to the special mode of management then being inaugurated. To indicate these changes, it may be stated that the rooms now, 1884, constructed for each prisoner, are eight feet wide, eighteen feet long, fourteen feet high, with double skylights in the ceiling, each five feet long by five and one-half inches inside width. There are air-tubes near the floor for outside ventilation. Each room has gas, fresh water, and a closet with perfect drainage, through a pipe four inches in diameter, into a ten-inch

main filled with water, flowing into a sewer, all flushed daily. The moral effect of these surroundings of each prisoner cannot be overestimated.

It was not until 1870 that the knowledge acquired by those directly connected with the administration of the Eastern State Penitentiary, was so thoroughly digested as to justify them in establishing the changes in the treatment of the prisoners, and the improvements in the buildings erected in 1877, which give to this institution its present characteristics. It is now attracting the close examination of the most enlightened men of America and Europe. France is earnestly investigating it, and the Prison Society of Paris preëminently leads the exposition of its methods. These changes from the original structure of the cells, and the relations of the prison authorities with the prisoners are best described as radical. Philosophy has consummated what philanthropy originated, and experience has developed what the founders of the Pennsylvania prison system were not gifted to foresee. These men, worthy as they are of the highest commendation, began an experiment out of which have been evolved principles of science that, now in operation, create new and distinctive duties and responsibilities between society and its criminals.

The present system of convict punishment as administered in the Eastern State Penitentiary can best be described as the individual treatment method of applying punishment for crime. It formulates this reform on positive philosophic principles.

The individual commits crime from motives with which the will, characteristics, inherited traits and training are related. This crime-cause is different in each case. The crime is the development of these concurrent influences. Society has suffered by the act of this person. It demands an expiation in some sort for the premeditated wrong. Security for either the rights of property or the rights of persons has been impaired by this act. The offender must be punished. It must be an example expressing the supremacy of law, the prevention of crime, and the purpose of restoring the offenders to society, instructed and strengthened, if so be, for good citizenship. The offender is convicted for the crime and the court sentences him to imprisonment. He is thus placed where his punishment can be applied. From the conception of the crime, in its commission, at the trial, conviction and sentence, the prisoner's individuality asserts itself. These antecedents crystallize round the individual. His punishment, to be effective, should therefore be applied to him as an individual. Separated from all other prisoners, the means which his case requires can be best discovered and best adapted to obtain the result society demands.

Under these conditions each prisoner is subjected to the discipline. Whatever may serve to elevate his moral character and strengthen it, to induce reform and inspire better aims in life, are addressed to his developing remorse. Special aptitudes and particular capacities are cultivated. Books for instruction and labor for training to industry are regarded as essential. A certain sum is allowed, over the cost of maintenance, for the prisoner to aid in the support of his family, or for himself when he is

released. Visits from his family and judicious persons are encouraged. Every prisoner is, therefore, treated as his case requires. The purpose as to each of all is to try and change his course of life, and thus benefit him and society. It is believed this method is successful in a large majority of first convictions of first offenders.

Incarceration is not punishment, it is only the condition under which it may reasonably be applied. Continuous labor during incarceration does not in itself constitute the entirety of punishment. It should be, however, adopted as an instruction, an element or marked feature in the discipline, with other instructions in the process of making punishment a personal benefit and an advantage to the public. Teaching a prisoner a trade, by which he may become self-supporting on his release from punishment, is a gain both for him and the community. That is labor which pays in morals, and as an industry intended to be both punitive and reformatory, it pays as an economy. It is doubtful if the man or the State gains any practical good by the incarceration at labor only, of violators of law. It is not doubtful that the outcome of congregating convicts at labor as their only punishment is dangerous to the general security. From this association a crime-class is established to war on the general welfare as its occupation. Punishment should attempt to reconstruct the enfeebled or irrational or misdirected character.

To discover the crime-cause, the weaknesses, the untaught and corrupted conditions and the positive needs of each convict is the antecedent of any rational method for his treatment in prison, and for the application of any moral alterative or corrective. This is undoubtedly the purpose, the aim and the gain of punishment. In this view the subject is elevated out of the domain of benevolence to the character of an important social science. It is this philosophy which regulates and characterizes the individual treatment of the Eastern State Penitentiary. To attain this purpose requires trained and competent officials, who, by long service, become qualified for their duties. It must be for them a vocation. Their tenure of positions must originate in high character, and continue with their usefulness in their responsible trust.

In the fifty-three annual reports of the Inspectors of the Eastern State Penitentiary will be found the history of the growth of the experiment which originated in Philadelphia a century ago. These reports, from the year 1829 to the present time, contain very interesting descriptions of the merits, and the objections to the separate system, and, from 1870 to 1883 inclusive, a thorough explanation of the changes and improvements in the system, and an exposition of the scientific principles which underlie them.

It may be justly claimed that the reforms in prison systems, or their administration, in the United States, as well as in foreign countries, are the out-come of the century of labors, efforts, and experience of the benevolent and philosophic men who in Philadelphia originated and have given to the Pennsylvania system its renown.

And it may with equal justice be maintained that those reforms in con-

vict punishment which are now so general are identified with the initial experiment in the Commonwealth of Pennsylvania.

It would doubtless be out of place in this paper to discuss the evils which attach to the profit-making congregate prisons.

The peril to society, the corrupting influences, the degradation and training in crime, which are inseparably connected with association of convicts, must exist while it is maintained.

It need only be stated that in old communities, or States where those who are convicted of crimes, of whatever physical and mental condition, capables and incapables, are indiscriminately incarcerated in a prison on the congregate, profit-making, self-supporting plan, the outcome exceeds the income. As a fact, under all the circumstances, such institutions cannot be proved to yield a profit to the State.

The theory of self-supporting congregate prisons under the conditions just mentioned is not always sustained. The sturdy adults, selected from the aggregate of all persons convicted in a State, may yield by their associate labor a profit to the prison. If so, then such a prison is a State manufactory. This is not regarded as a judicious adaptation of the purpose of a penal institution for the punishment of offenders against social security.

The State Penitentiary at Philadelphia is the only institution in the United States in which the "Individual treatment system" is administered. In England some of its features are engrafted on the penal discipline of its prisons, so far as the social conditions of that country accept them as practical. In France, Belgium, and Italy, greater progress than elsewhere in Europe has been made in adopting the separate plan in the prisons of those nations.

In some of the States of the Union there is a gradual approach to the principle of separation of convicts in prison, and a tacit acknowledgment of the value of the Pennsylvania system. The chief obstacle to a more thorough conformity is the proclaimed cost. It is hardly possible to convince those who legislate for, or conduct State penal institutions, even in States claiming to be enlightened, that any plan which does not pay its expenses is for the general interest of the people. Under this pretext this general delusion is vitalized. Till it shall be acknowledged a delusion, and the substantial interests of the public best considered by adopting the reform which is slowly manifesting its value, the Pennsylvania system must wait for its coming triumph. How long a period may intervene is problematical. Be it as it may, it must not deter or dishearten. The process of development in social science is necessarily deliberate. The consideration and clear comprehension of the relations of society to the violators of its laws are unattractive to the mind of the public. The code defining crimes changes as social conditions change. Education, heredity, customs, prejudices, false training, insubordination, and bad association, are among the incentives to unregulated individual conduct in communities, and thence crime is the outcome. How to deal with these

changing social growths is best to be found in the philosophy of the individual treatment of crime-cause, and its appropriate remedies.

That such a conclusion will be reached, as penology is studied, is most likely. If so, it will be the conviction of the judgment which comes from the demonstration of the principles which, since 1790, in this city have been taught as the science of convict punishment. This advance will be slow. It must be remembered that Beccaria in his essay on "Crimes and Punishment" in 1764; Filangieri in his "Science of Legislation" in 1780 and Montesquieu in his "Spirit of the Laws," 1748, were among the first to invite attention to penal jurisprudence. A century elapsed before practical advantages testified to the effect produced from this discussion of the subject. The Pennsylvania prison system rests its claim for recognition and adoption on the suggestions of philosophy, and the teaching of experience, confirmed by half a century of trial. It must teach, and wait.

Notes on the Stromateidæ. By Theodore Gill.

(*Read before the American Philosophical Society, July 18th, 1884.*)

The grave errors into which Dr. Günther seems to have fallen in the treatment of certain forms of this family furnish my excuse for the present communication. Dr. Günther has reiterated, without change, opinions enunciated twenty years ago, and he still separates widely forms of one of the subfamilies of this family, dispersing representatives thereof among four of his "families" and associating them in several cases with forms with which they have no affinity. Following Dr. Günther in the first instance Dr. Day has also misunderstood one of the types in question, and Dr. Lütken has likewise been deceived as to the relationships of the same form.

The family, as here understood, is co-equal with the Stromateidæ of Dr. Günther, with the addition of several types widely scattered by that gentleman. It embraces in fact, (1) the Stromateidæ recognized as such by Dr. Günther, (2) the genus *Pammelus* of his *Carangidæ*, (3) the species *Psenes anomalus* of his *Nomeidæ*, and (4) the genus *Schedophilus* of his *Coryphænidæ*. There are two quite distinct types in the group thus constituted, (1) one represented by *Stromateus* and its allies, and (2) the other by *Centrolophus* and relatives. These are distinguished by differences in the development of the vertebræ, the former having 14–15 abdominal and 17–21 caudal vertebræ, and the latter 11 abdominal and 14 caudal vertebræ; these differences are supplemented by variations in the degree of complexity of the peculiar appendages representing and homologous with the gill-rakers of ordinary fishes, developed from the last branchial arch, and extending into the œsophagus. It is quite possible, therefore, that the two types, now retained as sub-families under the old names *Stroma-*

teinæ and *Centrolophinæ*, should be distinguished as families. It is only the want of sufficient data respecting the several genera that delays such a recognition at the present time.

The Centrolophinæ appear to be the most generalized type, the ventrals being fully developed and retained in all stages, the dorsal and anal spines normally developed, and the preoperculum in some always retaining the spines characteristic of the youth of the Scombroid fishes, while the Stromateinæ contrast more or less in all these several features, and also have more specialized gill-rakers or processes.

A summary of the known types of the family will give the means of better appreciating the relations of the forms to be specially considered.

Family STROMATEIDÆ.

Synonymy.

>Stromatini, *Rafinesque*, Indice d'Ittiolog. Siciliana, p. 39, 1810.
×Fiatolides, *Risso*, Hist. Nat. de l'Europe Mérid., t. 3, pp. 107, 287, 1826.
×Stromateidæ, *Adams*, Manual Nat. Hist., p. 98, 1854.
>Stomateidæ, *Günther*, Archiv für Naturg., 28. Jahrg., B. 1, p. 59, 1862.
=————, *Gill*, Proc. Acad. Nat. Sci. Phila. [v. 14], p. 126, 1862.
(Indicated but not named or defined.)
>Stromatei, *Fitzinger*, Sitzungsber. K. Akad. der Wissench. (Wien), B. 67, 1. Abth., p. 32, 1873.
>Stromateidæ, *Günther*, Int. to Study of Fishes, p. 452, 1880.
=Stromateidæ, *Jordan and Gilbert*, Syn. Fishes N. Am., p. 449, 1882.
Scombroides gen., *Cuvier et al.*
Psettoidei gen., *Bleeker.*
Coryphænoidei gen., *Bleeker.*
Coryphænidæ gen., *Günther.*
Carangidæ gen., *Günther.*
Nomeidæ sp., *Günther.*

Scombroidea with an elongated dorsal whose foremost rays only are more or less spiniform and the gill-rakers of the upper segment of the last branchial arch enlarged and dentigerous or sacciform, and projecting backwards into the œsophagus.*

Body generally compressed, with the form regularly ovate or sub-orbicular, but sometimes more or less oblong or elongate, highest near the scapular region, and with the caudal peduncle suddenly constricted and slender.

Anus in the anterior half of the body.

Scales small, cycloid and smooth.

Lateral line nearly concurrent with the dorsal outline.

Head compressed, generally higher than long, with the profile more or less decurved in proportion to the height, and with the snout more or less convex. Eyes submedian or anterior.

*"The œsophagus is armed with numerous bony, barbed teeth," *Günther*, Cat. Fishes B. M., v. 2, p. 307.

Suborbital bones small.

Opercular bones normally developed

Nostrils double, in front of each eye.

Mouth terminal, moderate or small, with the cleft lateral and little oblique.

Upper jaw in some (Stromateinæ) not protractile, in others (Centrolophinæ) protractile.

Teeth small and pointed, absent from the palate.

Branchial apertures variable.

Branchiostegal rays variable (5 to 7).

Dorsal fin commencing at the nape or behind the bases of the pectorals, elongated, and with few small or rudimentary and often modified spines in front; the soft rays branched.

Anal fin commencing behind the anus and coterminal with the dorsal, to which it is similar in form and structure, but with fewer spines in front.

Caudal fin more or less emarginated or forked.

Pectoral fins inserted rather high on the sides, well developed and pointed or rounded.

Ventral fins thoracic or jugular when present, often absent (obsolete in the old, but developed in the young of some species).

Branchiæ 4, with a cleft behind the last.

Pseudobranchiæ developed.

The *pharyngeal bones* beneath are separated.

The *stomach* is cœcal, and the *pyloric appendages* in some numerous or dendritic, and in others developed in moderate number.

Subfamily CENTROLOPHINÆ.

Synonymy.

=Centrolophinæ, *Gill*, Cat. Fishes E. Coast N. Am., p. 34 (not defined), 1861.

=Centrolophinæ, *Gill*, Proc. Acad. Nat. Sci. Phila., p. 127 (not defined, but genera enumerated), 1862.

=Centrolophinæ, *Jordan and Gilbert*, Syn. Fishes N. Am., p. 450, 1882.

Coryphæniniæ gen., *Bonaparte*, 1831, 1838, 1840, 1846, 1850.

Stromateina gen., *Günther*.

Coryphænina gen., *Günther*.

Carangina gen., *Günther*.

Nomeina sp., *Günther*.

Stromateidæ with complex elongate gill-rakers, extending backwards from the epibranchials of the last branchial arch, 11 abdominal and 14 caudal vertebræ, protractile premaxillaries, and normally developed ventral fins (1.5) persistent through life.

Although the constituents of this subfamily have been widely scattered, and still continue to be, their relations were appreciated and contended

for more than a score of years ago. One of the genera has had a singular history, which may be detailed more at length hereafter. Suffice it now to state that one species was originally described as a *Centrolophus*, and subsequently differentiated as a peculiar generic type under the names *Leirus* and *Mupus*, while another closely related was originally introduced as a *Coryphæna*, again as a *Trachynotus*, and afterwards distinguished as a new genus *Palinurus*, near *Trachynotus*. The name *Palinurichthys*, was substituted for it Nov., 1859, by Bleeker and about the same time,* in Jan., 1860 (Proc. Acad. Nat. Sci., Phila., 1860, p. 20), Gill also independently proposed the name *Palinurichthys* as a substitute for *Palinurus*. In the "Catalogue of Fishes of the Eastern Coast of North America," published in Feb., 1861 (p. 34), it was referred to the sub-family Centrolophinæ. In critical remarks on Dr. Günther's composition of the Scombroid families ("On the Limits and Arrangement of the Family of Scombroids"), published in March, 1862 (Proc. Acad. Nat. Sci. Phila., 1862, p. 127), it was claimed that "nearly allied to the preceding [Stromateinæ] are the Centrolophinæ, with the genera *Centrolophus* Lac., *Leirus* Lowe, and *Palinurichthys* Gill, Blkr. (=Pammelas Gthr.). Closely connected to the Centrolophinæ are the genera *Schedophilus* Cocco and *Hoplocoryphis* Gill (type *Schedophilus maculatus* Gthr.)." A few lines further it was again remarked that among the forms that should be withdrawn from the Carangidæ was "*Pammelas* Gthr., which is nearly allied to *Centrolophus*." Finally, in Gill's new "Catalogue of the Fishes of the Eastern Coast of North America" (1872, p. 9), *Palinurichthys* was enumerated under the family "Stromateidæ" and the subfamily "Centrolophinæ." Notwithstanding these explicit statements the genus has been retained by Dr. Günther and Dr. Day next to *Trachynotus*, with which it has no affinity whatever. Its anatomy conclusively shows that the view, originally formed by the author from a consideration of its exterior, is perfectly correct. It has the number of vertebræ, epibranchial processes, &c., of *Centrolophus*, and in fact is scarcely, if at all, distinguishable from *C. ovalis* of European authors.

Centrolophus.

Synonymy.

=Centrolophus, *Lacépède*, Hist. Nat. des Poissons, t. 4, p. 441, 1802.
<Centrolophus, *Cuvier*, Règne Animal, 2 ed., t. 2, p. 216, 1829.
<Acentrolophus, *Nardo*, Prodr. Ichthyol. Adriat., sp.
<Centrolophus, *Cuvier and Valenciennes*, Hist. Nat. des Poissons, t. 9, p. 330, 1833.
=Pompilus, *Lowe*, Proc. Zool. Soc. London, 1839, p. 81.
Coryphæna sp., *Linnæus*, etc.
Perca sp., *Gmelin*.
Holocentrus sp., *Lacépede*.

*The paper in the Proc. Acad. was probably published earlier than Dr. Bleeker's, but happily the question is immaterial.

Centrolophinæ with an elongated body, and very slender spines, scarcely distinguishable externally from the succeeding rays.

Type *C. pompilus* = *Coryphæna pompilus* Linn.

Schedophilus.

Synonymy.

=Schedophilus, *Cocco*, Giorn. Innom. Messin., anno 3, No. 57, p. 57 (fide Bon.) 1834?

=Schedophilus, *Bonaparte*, Fauna Italica, iv, Pesci, fol. 127 (marked 132), 1839.

Centrolophus sp., *Cocco*.

Crius sp., *Valenciennes*.

Centrolophinæ with an oval contour, about four short, stout spines constituting the foremost part of the dorsal, and a declivous or slightly protuberant snout.

S. medusophagus = *Centrolophus medusophagus* Cocco.

The generic characters of this type, if distinct, have not yet been satisfactorily contrasted with those of *Leirus*. There is a singular discrepancy between the several figures of the types, most of which can, however, be satisfactorily accounted for.

Leirus.

Synonymy.

??Lepterus, *Rafinesque*, Caratterī di alcuni n. gen. e n. sp. Animali e Piante della Sicilia, p. 52, pl. 10 (D. ii, 30; A. i, 14; P. 20; V. i,5), 1810.

??Lepipterus, *Rafinesque*, Indice d'Ittiologia Siciliana, p. 16, 1810.

=Leirus, *Lowe*, Proc. Comm. Zool. Soc., London, pt. 1, p. 143; Trans. Cambridge Phil. Soc., v. 6, p. 199, pl. 5, 1833.

=Mupus, *Cocco*, Giorn. Innom. Messin. ann. —, p. —.

<Crius, *Valenciennes*, Hist. Nat. des Iles Canaries, par Webb and Berthelot, t. 2, part 2, Poissons, p. 45, 1836–44.

=Palinurus, *Dekay*, Zoology of New York, pt. 4, p. 118, 1842.

=Mupus (*Cocco*), *Bonaparte*, Cat. Met. dei Pesci Europei, p. 77 (name only), 1846.

=Palinurichthys, *Bleeker*, Enum. sp. Pisc. Archipel. Ind., p. 22, Nov., 1859.

=Palinurichthys, *Gill*, Proc. Acad. Nat. Sci. Phila. [v. 12], p. 20, Jan., 1860.

=Pammelas, *Günther*, Cat. Fishes in Brit. Mus., v. 2, p. 485, 1860.

=Leirus, *Jordan and Gilbert*, Syn. Fishes N. Am., p. 452, 1882.

Coryphæna sp., *Mitchill*.

Trachinotus sp., *Storer*.

Centrolophus sp., *Cuv. and Val.*, *Günther*, etc.

Pompilus sp., *Lowe*.

Centrolophinæ with an oval contour, six to eight short stout spines constituting the foremost part of the dorsal, and a protuberant snout.

Type *L. ovalis* =*Centrolophus ovalis*, C. V.

It is possible, perhaps probable, that the fish from which the following very unsatisfactory description was taken by Rafinesque was a specimen of the typical species of this genus.

"XXXIII. G. LEPTERUS.—Capo troncato senza squame, dei denti alla mascella, inferiore sola nente, opercolo doppio, l'esterne spinoso, l'interno dentelato, base dell'ale dorsale, anale e caudale [p. 53] ricoperte *di* squame, una sola ala dorsale con pochi raggi spinosi.—*Oss.* Il Carattere che distingue particolarmente questo genere dall' *Holocentrus* si è quello delle sue ale squamose.

"142. *Sp.* LEPTERUS FETULA.—Nero al disopra, bianco al disatto, linea laterale curva nel mezzo, coda forcata, ala dorsale con 32 raggi di cui 2 spinosi, l'ala anale con 15 di cui 1 è spinoso.—*Oss.* Porta il nome di *Fetula*, è raro e poco stimato, ha alcuni piccoli denti acuti alla parte anteriore della mascella inferiore, l' iride bianca, le ale pettorali con 20 raggi e le toraciche con 6 di cui il primo 6 spinoso ; la sua lunghezza è di circa mezzo piede."

Subfamily STROMATEINÆ.

Synonymy.

×Stromatia, *Rafinesque*, Analyse de la Nature, p. —, 1815.
<Stromateini, *Bonaparte*, Iconografia della Fauna, Italica, t. 3, Pesci, fol. 125 (contains *Stromateus*, *Peprilus*, *Luvarus* and *Kurtus*), 1834.
<Stromatinæ, *Swainson*, Nat. Hist. and Class. Fishes, etc., v. 2, pp. 177, 253, 1839. (Includes *Sesirinus*, *Stromateus*, *Peprilus*, *Kurtus* and *Keris*.)
<Stromateini, *Bonaparte*, Nuovi Annali delle Sci. Nat., t. 2, p 133, 1838 ; t. 4, p. 275, 1840.
<Stromateina, *Günther*, Cat. Fishes in Brit. Mus., v. 2, pp. 355, 397, 1860.
=Stromateinæ, *Gill*, Cat. Fishes E. Coast N. America, p. 35, 1861.
=Stromateinæ, *Gill*, Proc. Acad. Nat. Sci. Phila., 1862, p. 126, 1862.
=Stromateinæ, *Jordan and Gilbert*, Syn. Fishes N. Am., p. 450, 1882.

Stromateidæ with 14–15 abdominal and 17–21 caudal vertebræ, sacciform processes extending backwards from the hindmost branchial arch, non-protractile premaxillaries, and with the ventral fins generally early atrophied or lost, and absent in adult—rarely persistent.

Dr. Lütken recognizes two genera of Stromateinæ, viz. :

I. STROMATEUS.

Stromateinæ with ample branchial apertures.

In 1862 Gill proposed to subdivide this type into four genera or subgenera, viz. :

1. STROMATEUS.

Synonymy.

<Stromateus, *Artedi*, Genera Piscium, p. 19, 1738.
<Stromateus, *Linnæus*, Systema Nature, ed. x, t. 1, p. 248, 1758; ed. xii, t. 1, p. 432, 1766.
×Chrysostrome, *Lacépède*, Hist. Nat. des Poissons, t. 4, p. 698, 1802.
<Fiatola, *Cuvier*, Règne Animal [1re éd.], t. 2, p. 342, 1817. (Subgenus.)
<Stromateus, *Cuvier*, Règne Animal [2e éd.], t. 2, p. 212, 1829.
>Seserinus, *Cuvier*, Règne Animal [2e ed.], t. 2, p. 214, 1829.
<Stromateus, *Cuv. & Val.*, Hist. Nat. des Poissons, t. 9, p. 372, 1833.
×Stromateus, *Günther*, Cat. Fishes in Brit. Mus., v. 2, p. 397, 1860.
=Stromateus, *Gill*, Proc. Acad. Nat. Sci. Phila. [v. 14], p. 126, 1862.
Stromateus sp. *auct.*

Stromatei with uniform dorsum, little produced dorsal and anal fins, and without an obvious pelvic spine.

Type *S. fiatola* Linn.

2. PEPRILUS.

Synonymy.

<Peprilus, *Cuvier*, Règne Animal [2e ed.], t. 2, p. 213, 1829.
<Rhombus, *Cuvier and Valenciennes*, Hist. Nat. des Poissons, t. 9, p. 401, 1833.
Chætodon sp., *Linn.*
Sternoptyx sp. *Bloch and Schneider.*
Stromateus sp., *Mitchill*, etc.

Stromatei with uniform dorsum, dorsal and anal fins extended vertically in front, and with a trenchant pelvic spine.

Type *P. alepidotus* = *P. longipinnis* Cuv., ex. Mitchill.

3. PORONOTUS.

Synonymy.

=Poronotus, *Gill*, Cat. Fishes E. Coast N. Am., p. (not defined), 1861.
Stromateus sp., *Peck*, etc.
Peprilus sp., *Cuv.*
Rhombus sp., *Cuv. and Val.*

Stromatei with a row of vertical slits on each side of the back between the dorsal fin and lateral line, with little extended vertical fins, and with a trenchant pelvic spine.

Type *P. triacanthus* = *Strom. triacanthus* Peck.

4. APOLECTUS.

Synonymy.

=Apolectus, *Cuv. and Val.* Hist. Nat. des Poissons, t. 9, p. 438, 1833.
Stromateus sp. *Bloch, Bleeker*, etc.

Stromatei with the lateral line keeled and shielded behind.

Type *A. niger* = *A. stromateus Cuv. and Val.*

II. STROMATEOIDES.

Stromateinæ with restricted branchial apertures and without ventrals. There appears to be two types under this group, viz:—

1. STROMATEOIDES.

Synonymy.

<Pamples, *Cuvier*, Règne Animal [2e ed.], t. 2, p. 212, 1829.
<Pampus, *Bonaparte*, Fauna Italica, iii, Pesci, fol. 125,* 1834.
<Stromateoides, *Bleeker*, Bijdrage tot de kennis der makreelachtige Vischen van den Soenda-molukschen archipel, pp. 19–20, *in* Verhandl. bataav. Genootsch., v. 24, 1857.
<Stromatecides, *Lütken*, Vidensk Selsk. Skr. (5), Nat. og Mathem. Afd., v. 12, pp. 523, 602, 1880.
Stromateus sp., *Bloch*, *Günther*, etc.

Stromateoides with higher body, elevated vertical fins, and prominent and extended trenchant dorsal and anal spines.

Type *S. cinereus* Blkr., ex Bloch.

2. CHONDROPLITES.

Synonymy.

=Chondroplites, *Gill*, Proc. Acad. Nat. Sci. Phila. [v. 14], p. 126 (not defined), 1862.
Stromateus sp., *Euphrasen*, etc.
Stromateoides sp., *Bleeker*. *Lütken*.

Stromateoides with more oblong body, little elevated dorsal and anal fins, and concealed and subcartilaginous dorsal and anal spines.

Type *C. sinensis* = *Strom. sinensis*, Euphrasen.

PSENOPSIS.

Synonymy.

=Psenopsis, *Gill*, Proc. Acad. Nat. Sci. Phila., 1862, p. 157, 1862.
Trachinotus sp., *Temminck and Schlegel*.
Psenes sp., *Bleeker*, *Günther*, *Lütken*.

Stromateinæ with persistent perfect ventrals (I, 5) and about 6 normal spines constituting the front of the dorsal fin.

Type *P. anomalus* = *Trachinotus anomalus*, T. and S.

The following genus may be mentioned in this connection because the *Leirus perciformis* as well as *Psenopsis anomalus* have been referred to it. Its affinities are uncertain.

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* "Diamo il nome di *Pampus* al secondo sottogenere in cui accogliamo quelle specie che non hanno pinne ventrali, e portano innanzi ai raggi delle dorsali e dell' anale parecchie spine terminate superiormente da una lamina tagliente." Bonaparte.

PROC. AMER. PHILOS. SOC. XXI. 116. 4G. PRINTED OCT. 29, 1884.

PSENES.

Synonymy.

Psenes, *Cuvier and Valenciennes*, Hist. Nat. des Poissons, t. 9, p. 259.
Cubiceps, *Lowe*, Proc. Zool. Soc. London, p. 82, 1843.
Atimostoma, *Smith*, Illust. Zool. S. Africa Fishes.
Navarchus, *Filippi and Verany*, Mem. Acad. Sci. Torin. (2), t. 18.
Trachelocirrhus, *Doumet*, Revue et Mag. de Zool., t. 15, p. 212, 425, etc., 1863.
Cubiceps, *Günther*, Cat. Fishes in Brit. Mus., v. 2, p. 388, 1860.
Psenes, *Günther*, Cat. Fishes in Brit. Mus., v. 2, p. 494, 1860.

These synonyms are given chiefly on the authority of Dr. Lütken (Vidensk. Selsk. Skr. (5), Nat. og Math. Afd., v. 12, pt. 6, pp. 513, 601).

The genus named *Schedophilopsis* by Dr. Steindachner* under the supposition that it was nearly related to *Schedophilus*, has considerable superficial likeness to that genus, but apparently does not belong to the same family, and had received the slightly prior name *Icosteus*. It is the representative of a peculiar family, *Icosteidæ*, in Jordan and Gilbert's Synopsis (p. 619).

Stated Meeting, Aug. 15, 1884.

Present, 2 members.

An acceptance of membership was received from Dr. W. W. Keen, dated Philadelphia, July 19th, 1884.

Letters of acknowledgment were received from the New Bedford Library; Yale College; University of the City of New York and Prof. J. J. Stevenson; U. S. Naval Institute; Library of Congress; United States Surgeon-General's Office; United States Naval Observatory; United States Geological Survey, and the Chicago Historical Society (all for No. 115).

Donations to the Library were received from the Egyptian Institute; the Department of Mines, Melbourne; the Geological Survey of India; the Netherland Archives; the Royal Society of Northern Antiquaries; the Geological Society of Switz-

*Schedophilopsis = Schedophilopsis *Steindachner*, Anzeiger Math. Nat. cl R. Akad. Wissensch. zu Wien., 1881, p. 100 (*S. spinosus*), 1881.

erland; Prof. E. Renevier; the Society of Sciences at Liège; M. E. Folie; M. Paul Albrecht; the Reale Accademia dei Lincei; the Observatory at Turin; M. Alessandro Dorna; M. Damiano Muoni; the Revue Politique; the Ecole des Mines; the Geographical Societies of Paris and Bordeaux; the R. Academy of History in Madrid; the Royal Meteorological Society; London Nature; Mr. Benjamin Ward Richardson; M. F. Hugh O'Donnell; Rev. John Presland; Mr. Lewis Appleton; the Essex Institute; Prof. C. H. Hitchcock; the Boston Society of Natural History; the American Academy of Arts and Sciences; the Astronomical Observatory of Harvard College; the American Journal of Science; the New York Meteorological Observatory; the American Museum of Natural History; Mr. A. N. Bell; J. & J. D. Nolan; the College of Pharmacy; Franklin Institute; Pennsylvania Historical Society; the Engineer's Club; Mr. Benjamin S. Janney; M. Leopold Delisle; Dr. Persifor Frazer; Mr. E. D. Cope; Major M. Veale; the United States Naval Institute; Johns Hopkins University; Chief of Engineers, United States Army; United States National Museum; United States War Department; Mr. Jed. Hotchkiss; Mr. Wm. A. Courtnay; Rev. Stephen D. Peet; and the Academy of Science at St. Louis.

The death of Ferdinand Von Hochstetter, at Vienna, July 18, 1884, aged 55 years, was reported by the Secretary.

Communications from Prof. E. D. Cope were received as follows:

"On the Structure of the Feet in the Extinct Artiodactyla of North America."

"Fifth Contribution to the Knowledge of the Fauna of the Permian Formation in Texas."

The President reported that he had appointed Messrs. Lesley, Phillips, Ingham, Rushenberger, Barker and Brinton, to meet the requirements of the resolution of the Board and Council, adopted Feb. 8, 1884.

And the meeting was adjourned.

Stated Meeting Sept. 19, 1884.

Present, 4 members.

Letters accepting membership were received from Edward W. Syle, D.D., 609 Walnut Street, Philadelphia, August 29th; from Sir John Lubbock, dated High Elms, Hayes, Kent, August 6; and from N. A. Randolph, M.D., University of Pennsylvania, Medical Department, August 9, 1884.

Acknowledgments were received from the Cambridge Library, England (110, 111, 112); W. L. Stevens (115); the Royal Academy of Sciences and Royal Zoölogical Society, Amsterdam (110, 111, — 112); the Franklin Institute (115); and the Maryland Historical Society (115).

Letters of envoy were received from the Musée Guimet, August 23; the Manchester Library and Philosophical Society; and the Cambridge Library, England, June 30.

An invitation was received to assist at the Twenty-fifth Anniversary of the Natural History Society, at Chemnitz.

A circular letter was received from Gen. C. B. Norton, respecting the American Exhibition of 1886, at London.

Donations to the Library were received from the Geological Survey of India; the Academy of Sciences at Batavia; the Royal Society of New South Wales; the Office of Mines at Melbourne; the Royal Society of Tasmania; the Physical-Central Observatory at St. Petersburg; the Imperial Society of Naturalists at Moscow; the Imperial Royal Central Institute, Geological Reichsanstalt, Zoölogico-Botanical, and Geographical Societies at Wien; M. August Tischner at Leipzig; the Scientific Society of Upper Lusatia; the Royal Prussian Academy and German Geological Society at Berlin; the Royal Danish Society of Sciences; the Institute of the Grand Duchy of Luxembourg; the Royal Academy of Sciences at Amsterdam; the Holland Society of Sciences, and Tyler Museum; the Royal Academy of Sciences, Royal Observatory and Department of the Interior at Brussels; the Venetian Institute of Sciences; the Royal Academy of Sciences at Turin; the

Academy of the Lincei; the Royal Geological Committee of Italy; the Tuscan Society of Natural Sciences; the Anthropological, Zoölogical, and Geographical Societies at Paris; the Musée Guimet; the Royal Academy of History at Madrid; the Philosophical Society of Great Britain, the British Association for the Advancement of Science, Royal Observatory, Meteorological Office, International Forestry Exhibition, the Royal Asiatic, Geographical, Zoölogical, Geological, Astronomical, Linnean and Antiquarian Societies and Nature, London; the Royal Cornwall Polytechnic Society; the Manchester Literary and Philosophical Society; the Royal Irish Academy; the Royal Society of Canada; S. E. Cassino & Co.; American Philological Association; A. Agassiz and F. D. Whitney; the American Antiquarian Society; the American Journal of Science; the Torrey Botanical Club of New York; Dr. William G. Stevenson, of Poughkeepsie; the Franklin Institute, the College of Pharmacy, J. P. Lesley and Henry Phillips, Jr.; the American Chemical Journal, American Journal of Philology, Johns Hopkins University, and Edward Ingle, of Baltimore; the United States National Museum, the United States Fish Commission, the Smithsonian Institution, and Mrs Erminnie A. Smith, of Washington; J. Hotchkiss, of Staunton, Virginia; Charles Colcock Jones, Jr., of Atlanta, Georgia; the Colorado Scientific Society, and M. Rafael Mallen, of Mexico.

The death of Mr. Henry M. Phillips, at Philadelphia, August 29th, aged 73, was announced.

The death of Prof. Robert E. Rogers, M.D., at Philadelphia, September 6th, aged 77, was announced.

"Thermometrical Observations at Quito, Ecquador, taken by Mr. C. B. Brockway, from September 17, 1858, to June 18, 1859," was presented by the Secretary, with a letter from Mr. Brockway, dated September 6th, 1884, in which he says:

"I would call the attention of whoever examines the table to the equability of the temperature and that the heavy earthquake shocks did not materially vary it. Since Humboldt's stay at the Equator I think that no official observations have been taken."

And the meeting was adjourned.

Thermometrical Observations in Quito, Ecuador. Farenheit. C. B. Brockway.

(*Read before the American Philosophical Society, September 19, 1884.*)

DATED 1858.	9 A. M.	12 M.	3 P. M.	9 P. M.	REMARKS.
September 17			66°	64°	Elevation above sea level 9492 feet.
" 18	65°	66°	65	61	Latitude 0° 15′ S., Longitude 78° 45′ W.
" 19	63	65	63	61	
" 20	62	65	65	62	
" 21	60	62	62	61	
" 22	61	63	64	61	
" 23	61	63	63	62	
" 24	61	63	63	58	
" 25	60	63	62	60	
" 26	61	62½	62	58	
" 27	59	62	62	60	
" 28	60½	62	62	61	
" 29	60	62½	63	61	
" 30	61	64	62½	60	
October 1	59	60	60	56	Rain in the afternoon.
" 2	60	61	60	53	Rainy until near evening.
" 3	60	61	62	59	Clear.
" 4	60	61	63	54	"
" 5	59	62	64	53	Hail and rain in afternoon.
" 6	61	64	64	55	Clear.
" 7	61	63	64	55	Cloudy after 4 P.M.
" 8	62	63	64	54	Cloudy from 4 to 6 P.M. Comet visible in evening.
" 9	61	63	64	60	Morning and evening clear. A little rain in afternoon.
" 10	61	62	63	60	Clear.
" 11	59	62	64	55	"
" 12	54	62	63	56	"

October	13	60	63	64	56	Clear.
"	14	59	62	62	55	Cloudy all day.
"	15	58	61	62	55	" "
"	16	59	61	61	56	Clear.
"	17	56	62	63	54	"
"	18	62	65	62	54	Clear in forenoon. A little rain towards evening.
"	19	56	62	63	55	Cloudy part of the day.
"	20	56	63	62	53	Clear morning and evening. Cloudy at noon.
"	21	59	63	63	55	Clear morning. Sudden haze at dark for a few minutes.
"	22	61	62	64	54	Clear.
"	23	56	64	64	54	Clear in forenoon. Towards evening rain, thunder and lightning.
"	24	55	65	62	53	Clear in forenoon. Cloudy from 3 to 4 P.M.
"	25	59	62	63	55	Clear until evening, then rain.
"	26	60	62	62	53	Cloudy day and rainy evening.
"	27	55	64	65	56	Clear day and cloudy evening.
"	28	60	64	65	57	Clear day.
"	29	61	64	62	55	Clear forenoon. Rain in afternoon.
"	30	59	64	63	58	Hard shower in the afternoon.
"	31	63	65	66	55	Rain in afternoon.
November	1	64	66	63	54	Rain in afternoon and heavy thunder.
"	2	60	64	61	53	Hail large as peas; thunder and lightning all afternoon.
"	3	60	62	63	54	Cloudy; slight rain; a beautiful rainbow; first seen.
"	4	60	62	61	54	Cloudy all day. Heavy shower at 1 P.M.
"	5	58	59	59	51	Cloudy all day; gloomy; rainy all day.
"	6	61	63	62	54	Rain, thunder, lightning, in afternoon.
"	7	59	62	59	51	Clear morning. Rain in afternoon.
"	8	61	63	61	50	Rain in afternoon.
"	9	62	62	61	51	Clear morning. Rain in afternoon.
"	10	58	61	61	49	" " " "
"	11	61	63	62	52	Very little rain during the day.
"	12	61	61	62	48	Gloomy and rainy day. Beautiful and moonlight eve.
"	13	60	61	59	55	Slight rains in the afternoon.
"	14	59	61	59	53	A very hard shower accompanied by loud thunder.

Dated 1858.	9 A. M.	12 M.	3 P. M.	9 P. M.	REMARKS.
November 15	56°	59°	59°	51°	Cloudy all day. Rainy in afternoon.
" 16	61	62	62	52	Pleasant forenoon. Rainy in afternoon.
" 17	60	62	61	55	Rained in the night, a thing unusual.
" 18	62	64	63	53	Beautiful morning. Hard shower at 9 A.M.
" 19	59	62	61	54	Cloudy in the forenoon. Rain in afternoon.
" 20	59	61	61	54	Gloomy day, accompanied with rain.
" 21	58	60	61	54	Gloomy day; cloudy; no rain.
" 22	58	60	60	53	Gloomy day; cloudy; misty; no rain.
" 23	59	63	61	54	Sun again seen. Rain in afternoon.
" 24	60	61	62	54	Sun seen again. Shower at noon.
" 25	58	60	61	55	Gloomy day; a little rain; clear evening.
" 26	60	62	62	54	Gloomy day; hard shower in the evening.
" 27	59	60	59	53	Rained all day and night.
" 28	59	62	61	55	Pleasant morning. Hard showers all afternoon.
" 29	60	63	62	55	Clear day.
" 30	60	63	62	55	Hard shower at 9 P.M.
December 1	61	64	62	53	Forenoon pleasant. Showers at 3 P.M.
" 2	59	63	63	55	Cloudy all day; some rain.
" 3	63	64	63	53	Fine morning. Hard rain all afternoon.
" 4	61	61	62	54	A dismal day; hard rains.
" 5	61	62	62	53	A dismal day; some rain.
" 6	59	60	60	53	A dismal day; constant rains.
" 7	59	60	60	52	A shower about noon; pleasant afterwards.
" 8	59	60	60	53	Fine forenoon. Heavy showers all afternoon.
" 9	59	62	62	54	A pleasant day.
" 10	60	61	60	52	Rained some.
" 11	60	62	62	53	Fine forenoon. Showers in afternoon.
" 12	62	64	62	53	Pleasant until 3 P.M., then had a heavy thunder storm.
" 13	60	63	63	54	Thunder in afternoon. Rain in evening.
" 14	59	63	62	53	Pleasant forenoon; stormy afternoon.
" 15	60	63	61	52	Heavy thunder and hail storm about 2 P.M.; some rain.

December	16	61	63	62	55	Pleasant forenoon ; some rain after.
"	17	60	63	62	55	Some rain forenoon. Beautiful evening.
"	18	60	62	61	54	Hard showers in afternoon.
"	19	61	63	63	55	Clear day ; rain about 9 P.M.
"	20	62	65	64	55	Fine morning. Rain in afternoon.
"	21	61	63	64	56	Fine day.
"	22	61	63	63	57	"
"	23	62	63	63	56	Rain in the afternoon. Fine evening.
"	24	63	65	62	54	Fine morning. Rain most of the afternoon.
"	25	63	65	63	52	Fine morning. Rain towards evening.
"	26	62	63	62	54	Gloomy, drizzly, and rainy all day.
"	27	63	64	62	54	A fine morning ; the day ending in rain.
"	28	61	63	63	53	Clear.
"	29	62	64	63	53	Pleasant day; thunder, but no rain.
"	30	60	62	63	56	Rain about 9 A.M. Afternoon cloudy.
"	31	62	64	63	55	Drizzly rain from 3 P.M. and during the night.
1859.						
January	1	61	64	63	55	Rain from 1 to 3 P.M., afterwards clear.
"	2	59	61	62	55	Rain from 6 to 9 A.M., afterwards clear until 4 P.M.
"	3	62	64	63	50	Constant showers from 4 P.M until dark.
"	4	62	63	62	52	Rain, with sharp lightning and loud thunder from 2 to 5½ P.M.
"	5	61	63	63	52	Clear and beautiful.
"	6	60	62	64	54	Clear except a short time afternoon.
"	7	62	65	66	56	Cloudy afternoon ; Rain began at 8 P.M.
"	8	63	65	62	50	Rain during the afternoon.
"	9	61	60	61	53	Rainy day and evening.
"	10	62	63	63	53	Clear.
"	11	63	64	65	56	"
"	12	63	65	65	53	"
"	13	62	64	63	52	Rain and hail between 3 and 4 P.M.
"	14	62	64	64	55	Cloudy morning. Clear afternoon.
"	15	62	64	64	55	Slight rain towards night.
"	16	62	64	64	55	A few drops of rain about 5 P.M.
"	17	62	64	64	55	" " " "

Dated 1859.		9 A. M.	12 M.	3 P. M.	9 P. M.	Remarks.
January	18	62°	64°	64°	55°	Cloudy day; a little rain towards night.
"	19	61	63	63	57	Some rain last night. Cloudy day.
"	20	62	63	64	53	Clear.
"	21	60	62	63	51	Clear, except morning cloudy.
"	22	62	64	65	51	Hard showers; loud thunder; sharp lightning.
"	23	61	63	63	52	Pleasant forenoon. A little rain in afternoon.
"	24	61	64	63	54	Cloudy morning. Rain set in about dark.
"	25	61	64	64	53	Clear day; rain about 8 P.M.
"	26	62	65	65	54	A little rain about 3 P.M.
"	27	61	64	65	55	Clear.
"	28	63	66	65	56	Clear forenoon. Cloudy afternoon.
"	29	61	64	64	56	Rain during the afternoon.
"	30	62	64	64	56	" "
"	31	61	64	64	54	" "
February	1	61	64	65	58	Cloudy.
"	2	60	62	63	53	Rain in afternoon.
"	3	61	63	64	53	Rain at 3 P.M.
"	4	62	65	63	52	Hail at 1 P.M.
"	5	61	63	64	54	Clear.
"	6	62	63	64	54	"
"	7	61	64	65	59	Clear; rain night.
"	8	62	63	64	54	Cloudy; a little rain in night.
"	9	60	60	61	52	" " "
"	10	61	62	58	53	Rain 1 P. M.
"	11	60	63	63	54	Little rain 1 P.M.
"	12	61	64	64	57	Cloudy afternoon.
"	13	61	64	64	56	Rain between 3 and 4 P M.
"	14	62	65	63	57	Clear.
"	15	62	65	65	59	"
"	16	62	65	65	58	"
"	17	63	63	63	57	"

February	18	64	66	66	57	Clear.
"	19	64	68	69	57	Slight fall of rain.
"	20	62	65	66	58	Clear.
"	21	64	65	66	57	A little rain about dark. (There is no dusk under the Equator.)
"	22	64	66	66	56	Rainy afternoon.
"	23	64	65	66	56	" "
"	24	64	65	65	56	A little rain afternoon.
"	25	63	65	63	54	At noon commenced hailing, but finally turned to rain.
"	26	62	64	62	54	Rain most of the afternoon.
"	27	61	63	64	53	Clear.
"	28	63	65	66	57	"
March	1	61	63	65	57	Some rain after 4 P.M., and slight one in the morning.
"	2	62	64	63	55	" " " " "
"	3	60	62	63	54	Rain in afternoon and night.
"	4	60	61	61	54	Heavy shower in morning and afternoon.
"	5	60	62	59	49	Rainy day.
"	6	60	61	60	52	Rainy afternoon.
"	7	59	60	60	48	Rainy from 11 A.M. until night.
"	8	59	62	64	54	No rain until after 4 P.M.
"	9	61	63	63	57	" " "
"	10	62	63	66	55	" " "
"	11	60	63	62	57	" " " *Earthquake shock at 8 A.M.*
"	12	61	64	64	54	" " "
"	13	62	64	65	56	" " "
"	14	61	63	64	55	Clear.
"	15	62	64	66	59	"
"	16	61	63	64	56	Rain in afternoon.
"	17	63	65	65	57	" "
"	18	61	63	62	56	" "
"	19	59	61	60	55	" "
"	20	59	64	60	56	Hail and rain in afternoon.
"	21	59	62	60	55	Rain after 2 P.M.
"	22	59	62	62	57	Rain after dark. *Heavy earthquake shock at 8½ A.M.**
"	23	58	62	62	56	Rain after 4 P.M.

*For note see page 684.

Dated 1859.		9 A. M.	12 M.	3 P. M.	9 P. M.	Remarks.
March	24	60°	65°	64°	59°	Very little rain afternoon.
"	25	61	62	63	55	" "
"	26	58	61	63	54	Rain most all day.
"	27	59	60	60	55	" "
"	28	59	61	61	54	" "
"	29	59	62	59	53	" "
"	30	57	58	58	54	" "
"	31	57	58	57	53	" "
April	1	54	56	56	52	" "
"	2	59	58	57	51	Clear morning. Rain and hail from noon until 4 P.M.; then clear.
"	3	56	58	57	53	Rain from noon till night.
"	4	56	58	57	53	Rainy.
"	5	56	56	56	53	"
"	6	58	58	57	54	Clear until noon, after which, rain.
"	7	58	59	59	53	A little rain about 4 P.M.
"	8	56	59	59	54	Clear forenoon. Cloudy afternoon.
"	9	58	61	61	56	Some rain between 4 P.M. and dark.
"	10	58	60	60	55	" " " and at 9 P.M.
"	11	59	62	60	56	Rain in evening.
"	12	59	60	62	55	Clear.
"	13	58	59	59	54	"
"	14	58	61	61	55	A little rain at noon.
"	15	59	61	61	54	Clear.
"	16	59	63	61	55	"
"	17	60	63	61	54	"
"	18	60	63	63	55	A little rain about noon. Rained hard at 9 P.M.
"	19	61	62	60	53	A little rain about noon
"	20	59	62	63	57	Clear.
"	21	61	61	63	54	"
"	22	61	62	64	53	"

April	23	61	62	64	53	Cloudy.
"	24	59	61	61	56	A little rain about noon.
"	25	61	62	61	55	A hard shower a little after noon.
"	26	59	62	58	53	Cloudy afternoon and a little rain.
"	27	60	62	62	55	Rain and clouds most of the day.
"	28	60	63	62	56	Rain at noon and at 3 P.M.
"	29	60	63	60	55	Rain about 2 P.M.
"	30	60	61	61	54	Lightning, thunder and rain.
May	1	59	58	57	51	Rainy.
"	2	58	62	63	53	Clear.
"	3	59	59	58	53	Rainy.
"	4	59	60	60	53	"
"	5	60	62	61	53	Some rain in afternoon, with hail.
"	6	59	62	60	53	Rain, hail, thunder and lightning during afternoon.
"	7	59	62	61	54	A little rain about 4 P.M.
"	8	58	63	61	54	Cloudy and windy afternoon; thick fog between 7 and 8 P.M.
"	9	54	57	58	48	Rainy, but clear evening.
"	10	58	60	61	51	Hard showers with rain after 3 P.M.
"	11	58	62	60	51	Lightning, thunder and rain during afternoon.
"	12	58	62	60	52	Cloudy afternoon; a little rain about sunset.
"	13	57	59	59	51	A drizzling rain all day.
"	14	57	59	58	52	A cloudy day; rainy afternoon and evening.
"	15	57	59	58	54	Rain afternoon and night.
"	16	57	58	58	51	Rainy day and night.
"	17	56	57	57	51	Rainy afternoon.
"	18	56	59	58	52	Cloudy day; rain after 4 P.M.
"	19	55	55	56	54	Rainy afternoon. *Heavy earthquake shock after 3½ A.M.*
"	20	56	58	57	51	Cloudy and windy; rain in afternoon.
"	21	55	58	56	53	Cloudy.
"	22	55	59	59	54	Clear.
"	23	56	61	60	54	Cloudy and windy; in afternoon thunder and lightning.
"	24	56	58	58	50	Clear; windy afternoon for Quito.
"	25	56	59	60	49	Clear.
"	26	56	59	61	51	"

Dated 1859.		9 A. M.	12 M.	3 P. M.	9 P. M.	Remarks.
May	27	56°	60°	62°	49°	Clear.
"	28	56	61	62	53	"
"	29	58	62	61	50	"
"	30	58	61	62	56	"
"	31	60	65	65	56	"
June	1	59	65	63	56	"
"	2	60	64	65	56	" considerable wind.
"	3	60	63	64	56	"
"	4	60	64	65	54	"
"	5	60	64	64	54	"
"	6	60	64	64	56	" and windy.
"	7	61	64	65	55	" " about noon.
"	8	60	62	65	55	"
"	9	60	64	65	55	"
"	10	61	63	63	56	"
"	11	61	64	63	56	Some clouds ; rain after 4 P·M.
"	12	61	63	62	56	Clear until noon, then a shower.
"	13	61	63	63	57	Floating clouds all day.
"	14	61	63	64	53	Clear.
"	15	61	64	64	54	"
"	16	61	64	64	54	"
"	17	61	64	64	53	"
"	18	59	64	64	53	"

* On the 22d of March was one of the heaviest earthquakes that ever occurred in Ecuador, not only as to loss of life, but as to surface transformations. It may be noted that the temperature was comparatively unchanged.—C. B. B.

Stated Meeting, October 3, 1884.

Present, 7 members.

Mr. INGHAM in the Chair.

Letters of acknowledgment were received from McGill University (114) and J. H. C. Coffin (115).

Donations to the Library were received from the Department of Mines at Melbourne; the Geological Survey of India; the Imperial Society of Naturalists, at Moscow; the Venetian: Athenæum; Baron Ferd. von Mueller; Revue Politique; London Nature; the Philosophical and Literary Society at Leeds; the Alchemist of Montreal; the Boston Society of Natural History; the American Journal of Science; Mr. B. Silliman; the Connecticut Academy of Sciences; the Meteorological Observatory at New York; the Academy of Natural Sciences at Philadelphia; Mr. Henry Phillips, Jr.; the United States Geological Survey, the United States Fish Commission; the American Antiquarian; and Mr. J. B. Stallo.

Mr. J. Sutton Wall, of Monongahela City, Pa., exhibited a canvas tracing of a group of Indian pictures cut on the top and sides of a half-buried block of sandstone perched on the bluff of the Monongahela valley, in Fayette county, Pa., opposite Millsborough, at a height of 290 feet above the river. A photograph of the canvas was exhibited.

Also a photograph of a tracing of similar figures on the rock shore of the river near Geneva, now submerged by a new slackwater dam.

Also one of a carved rock on the Hamilton farm near the Evansville turnpike, six miles south-east from Morgantown, in West Virginia. This rock surface is vertical.

In answer to a question respecting the safety of such monuments, Mr. Wall replied that a fourth fine group, of which he had heard, was destroyed before he could obtain a tracing of it, the farmer who owned the land having blasted it up for foundation stone for his new house; and that the owner of the

large group on the canvas informed him of his intention to treat the perched rock in the same way, when he built his new barn.

On motion of Mr. Phillips, it was

Resolved, That the subject be referred to the consideration of the Board of Officers and Council at its next meeting, whether any steps can be taken by the Society to preserve such monuments from destruction.

Mr. Lesley read a Note on a possible origin of the Pshent.

Mr. E. B. Harden exhibited, through the Secretary, a square pipe of limonite, which had been deposited against the inside walls of a vertical wooden box, leading down to the sump of the Eagle shaft near Pottsville, Pa. The outside layer, first deposited, was a beautifully perfect fac-simile of the inside rough face of the boards, showing the grain, saw cuts, and knots in the wood. The whole specimen admirably illustrated the formation of selvage veins.*

Dr. Syle presented a copy of the Chinese translation of Herschel's Outlines of Astronomy, in three volumes, published at Shanghai, December, 1859.

Pending nominations Nos. 1029, 1030 were read.

The Kansas Academy of Science at Topeka was ordered to be placed on the list of corresponding societies for exchange of publications.

The request of the Journal of Associate Engineering Societies, Washington University, St. Louis, Mo. (Sept. 27), was referred to the Secretaries.

An appropriation was made for publishing a plate illustration for the Proceedings, No. 117.

The Hall Committee was authorized to prepare the north garrets for the reception of the stock of publications.

And the meeting adjourned.

*This specimen was analyzed by F. E. Bachman, Chemist of the Phœnix Iron Co., and found to consist of 76.17 per cent sesquioxide of iron. The residue contained very little silica.

PICTURE ROCK,

On Hamilton Farm, near the Evansville Pike,

[redacted]

WEST VIRGINIA.

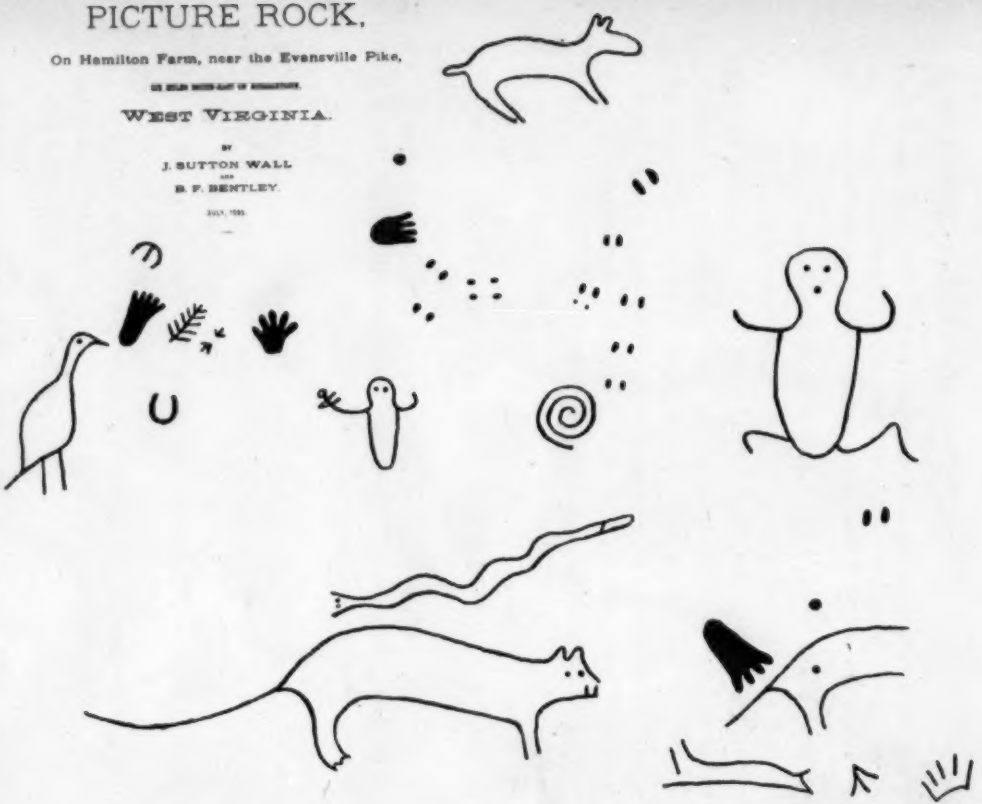
BY

J. SUTTON WALL

AND

B. F. BENTLEY.

JULY, 1884.



PICTURE ROCK,

On the shore of the

MONONGAHELA RIVER,

NEAR GENEVA, FAYETTE COUNTY, PA.

BY

J. SUTTON WALL

AND

WILLIAM ARISON.

PHOTOGRAPH FROM TRACING ON MUSLIN

OCTOBER, 1884.

Amer. Philos. Soc. Oct. 1884.

Photographic Reduction of Tracing on Muslin of

PICTURE ROCK,

On top of hill 200 feet above

MONONGAHELA RIVER,

OPPOSITE MILLSBOROUGH, FAYETTE COUNTY, PA.

BY

J. BUTTON WALL

AND

WILLIAM ARISON.

SEPTEMBER, 1883.

n Muslin of

CK,

ER.

E COUNTY, PA.

EAST END.

1884.

Photographic Reduction of Tracing on Muslin of

PICTURE ROCK,

On top of hill 200 feet above

MONONGAHELA RIVER,

OPPOSITE MILLSBOROUGH, FAYETTE COUNTY, PA.

BY

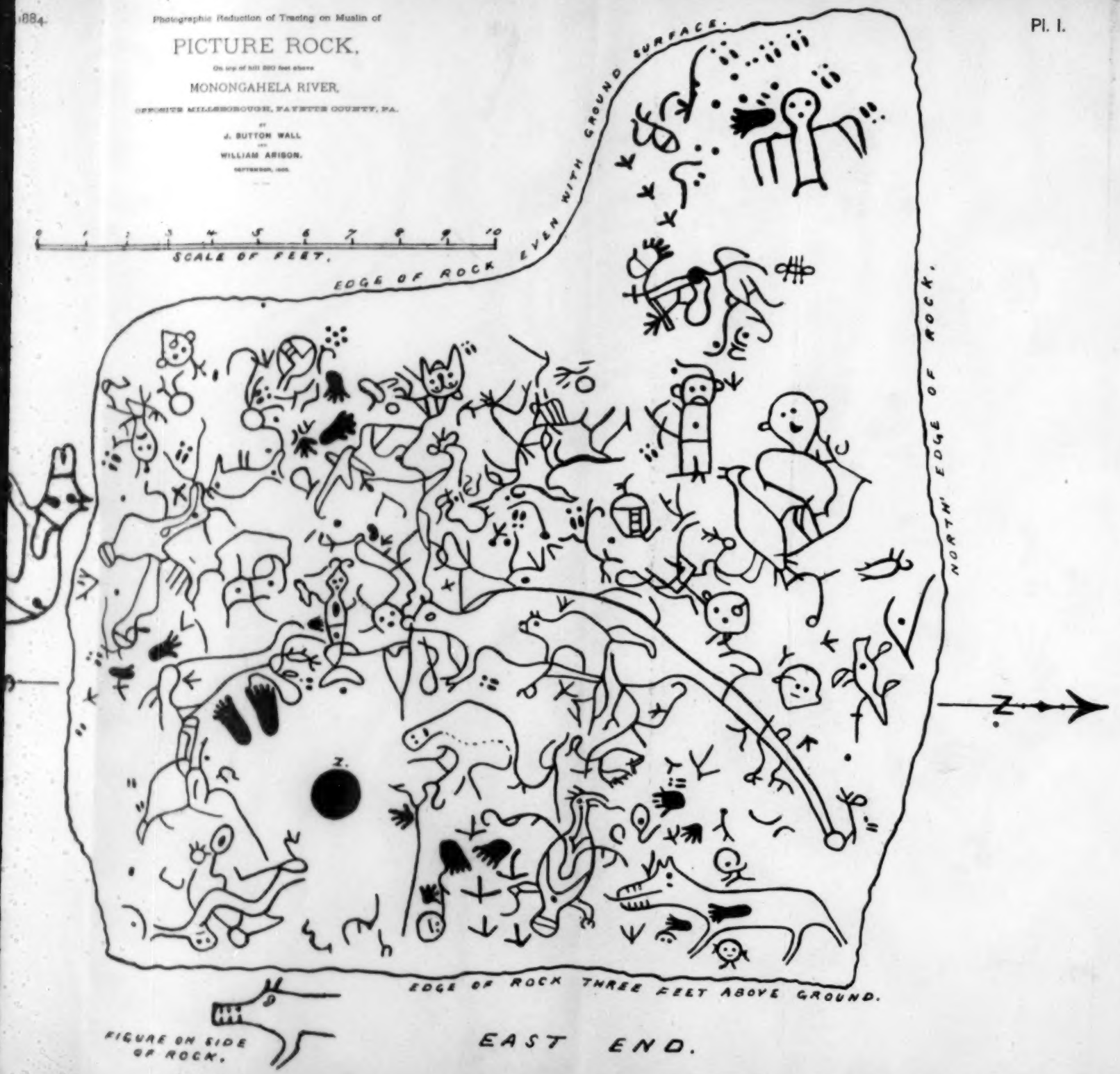
J. BUTTON WALL

AND

WILLIAM ARISON.

SEPTEMBER, 1884.

Pl. I.


0 1 2 3 4 5 6 7 8 9 10
SCALE OF FEET.
EDGE OF ROCK EVEN WITH GROUND SURFACE.
NORTH EDGE OF ROCK.
N.
Z.
EDGE OF ROCK THREE FEET ABOVE GROUND.
FIGURE ON SIDE OF ROCK.
EAST END.

On some Indian picture rocks in Fayette County, Pa. By Mr. J. Sutton Wall.

(*Read before the American Philosophical Society, Oct. 3, 1884.*)

The tracing on muslin (Plate I.), exhibited this evening, was made by Mr. William Arison, of Monongahela City, and myself, in the month of September, 1882.

This rock is perched on the crest of the hill facing the Monongahela river, opposite the town of Millsborough, at an elevation of 290 feet (by barometer) above water level of the river. It is a detached portion of the Waynesburgh sandstone which outcrops in the vicinity. Rather coarse in texture, it has a fairly even and smooth top surface, and is approximately sixteen feet square, with perpendicular sides. The top of the hill, next to the river, terminates rather sharply, and the ground surface receding from the river has a gradual fall of about ten feet per hundred for a distance of perhaps eighty yards, and then rises into a more elevated hill to the eastward of the rock. The rock occupies a position from which a very fine view of the river and Ten Mile valley can be had. The edge of the rock next to the river rests about even with the ground surface surrounding it, while the opposite edge rests about three feet above ground. It is not fissile and the top surface would be difficult to remove. The outlines of the figures are formed by grooves on channels smoothly and regularly cut or incised in the top surface and on two sides, of the width shown on the tracing, and are from three-fourths of an inch to a mere trace in depth. The foot-prints and cup-shaped cavities are carved about the same depth, except the large circular disc, which also is a cupped-shaped cavity, about five inches in depth. There are the outlines of two animals carved on the sides, one on the south side, which is shown on the tracing, and the other on the east side, not shown.

The figure composed of three connected links, with three lines or perhaps arrows drawn across them, I am inclined to place to the credit of vandalism, which is still in rapid progress, and will ultimately destroy the original carvings. Some of the lines are becoming quite faint, owing no doubt to erosion by the atmosphere. We only traced those lines and portions of lines that were distinctly legible.

Mr. Joseph Horner, and old resident of Millsborough, informs me that the figures were much more distinct, when he first saw them fifty years ago, than at the present time. A tradition exists in the neighborhood that the early settlers were informed by the Indians, that they had no knowledge of the authors of the carvings, but that they found them as the "white men" then saw them. The tracing shows all the figures reversed, but by looking through the canvas from the other side you can see them in their true position, which may be done by placing lights behind it. The tracing was made by painting the grooves and indentations with a mixture of lamp-black and turpentine, and then spreading strips of muslin over the portions painted, and by using a brush and our fingers,

the lines were transferred to the muslin ; after which it was sewed together in proper connection, and the lines made more permanent by repainting with diluted printers' ink. Mr. E. B. Harden, of the State Geological Survey, recently photographed a small portion of the top surface of the rock ; but was unable to obtain a proper position for photographing the whole surface. To do this properly an elevated position would be necessary at some distance from the rock. This could be done by the aid of a small amount of lumber and tools, which we did not have at hand at the time of our visit.

Plate 2 is a reduction from a tracing on muslin (natural size), showing the figures carved on the surface of a rock located on the east shore of the Monongahela river, a half mile below Geneva, in Fayette county, Pennsylvania. The rock has a fairly even and smooth upper surface, falling slightly toward the water, and is an eroded portion of the Morgantown sandstone in place. A portion of this rock containing figures was removed some years since, and used in constructing a building in Geneva. The figures thus removed I did not see.

The execution of the carvings appears to be of the same character as that on the rock shown by Plate 1. The marked resemblance of many of the figures leads me to consider it of the same age and origin as the other carved rocks in this region. At the time of my visit, in 1881, the upper portion of the rock rested only about four feet above low water, and I have since learned that the portion containing the figures copied has been rendered inaccessible by the back water, formed in the pool from the construction of Lock and Dam, No. 7, at a point nearly two miles farther down the river.

Plate 3 is also a reduction from a tracing of a carved rock located in West Virginia, near the north side of the Evansville pike, six miles southeast of Morgantown. This is along the crest of an elevated ridge, commanding a fine view of the surrounding country. The ridge on either side of this pike is strewn with numerous large blocks of sandstone, evidently detached from their native bed, and many of them present excellent surfaces for carving. But I only found two of them to contain any figures, out of a large number which I examined in the vicinity.

The figures shown on this plate were all found on one rock, and are represented in their true position. They are incised or cut in the top suface, evidently in the same manner as the rocks already mentioned. The small pot-shaped holes, buffalo and bear tracks form a common feature of all these pictured rocks. Each individual rock is however usually found to contain some figures not shown on others. Slight variations are also noticeable in the manner of representing certain animals and reptiles ; as for instance difference in posture. The rattlesnake is distinguishable by the line or bar which marks the termination of the body proper and shows the beginning of the rattles. The semi-circular figure on the left side of the plate forms, in my judgment, an interesting feature of this rock. It strikes me that this figure has been intended to represent a horse's track or foot-

print. If this interpretation be a correct one, it goes toward fixing the age of the workmanship, and brings it within the historic period of North America.

Stated Meeting, October 17, 1884.

Present, 15 members.

President, Mr. FRALEY, in the Chair.

A letter requesting exchanges was received from Mr. J. C. Rowell, Librarian of the University of California, dated Berkeley, October 1. On motion, the University of California was placed on the list to receive the Transactions and Proceedings from the beginning.

A letter requesting missing numbers of Transactions and Proceedings American Philosophical Society was received from the Imperial Society of Nature, Moscow, dated September 1.

Donations to the Library were reported from the Royal Society of Victoria; the Annales des Mines and Revue Politique; the Royal Academy of History at Madrid; the Meteorological Office, the Journal of Foresty and London Nature; Dr. Edward Jarvis, of Boston; Harvard University; the New York Academy of Sciences; the College of Pharmacy, the Franklin Institute, the Engineers' Club, the American Journal of Medical Sciences, Rev. E. W. Syle, Mr. Henry Phillips, Jr., and L. R. Hamersly, of Philadelphia; the Maryland Historical Society; the Bureau of Education, the United States National Museum and the Surgeon-General's Office at Washington.

A paper on *Herderite* was read by Dr. F. A. Genth.

A paper on the Language and Ethnographic position of the Xinka (Shinka) Indians of Guatemala was read by Dr. D. G. Brinton. The paper embraced two vocabularies of three dialects, the only known existing specimens of the language.

Dr. Syle objected to the statement made in the memoir that the absence of native names of *salt, maize,* &c., must necessarily be taken as evidence that the aboriginal Xinkas did not know, or possess the articles until the advent of their Aztec and Maya conquerors; adducing the fact that the

Japanese now use many Chinese names for things which they had before, and for which they had and still have their own names.

Mr. Phillips instanced the adoption of the word "alcohol" by the English, and their abandonment of "spirits of wine."

Dr. Brinton replied that the evidence was made stronger by the foreign words being repeated in all three dialects; and that comparative philologists recognize the rule as a good one, and the inference as reasonable, that if the Xinka vocabularies have no native word for hat, and have instead the Spanish word *sombrero*, the hat was probably not an article of native dress.

Mr. Ashburner described observations at the Luray caverns, and at the Natural Bridge, in Virginia, which he had made recently.

He found by barometric and by direct measurements that the traditionary data of the French Engineers were exaggerated. Instead of 215′, he made the crown of the arch 185′ and 187′ above the stream. Instead of the popularly received 2000′ above tide, his connections with the nearest railway station made the stream 915′, and the crown of the arch 1102′ A. T., and the Hotel 1040′. The thickness of the bridge at the north side is 46′; at the south side 36′.

Cedar creek flows beneath the bridge *southward*. The rock of the bridge is nearly horizontal. The rocks north of the bridge dip steeply towards it (*i. e.*, downstream, southward); those south of the bridge dip perceptibly also towards it (*i. e.*, upstream, northward). There is, therefore, a local synclinal at the bridge; and Mr. Ashburner would thus account for the existence of the bridge at that particular point. The last remnant of the roof of a long cavern, following a special stratum across a synclinal, would necessarily be left precisely in the axial line of the trough.

The Luray cavern ramifies to great distances, but always in a particular group of limestone beds, limited to 65 feet. The cavern of the Natural Bridge must have been limited to a certain soluble horizon of the formation. Its great height now is no safe index of the height of the cavern formerly; nor of the width of the soluble rock zone; but is to be ascribed to the vertical erosion of its channel by Cedar creek, in adjusting its water slope to the neighboring open lower country.

Dr. Frazer remarked that when he visited the Bridge three years ago he noticed steep (45°±) dips further south; and therefore that the synclinal must be very local.

Dr. Frazer desired to place on record his dissent from Prof. H. C. Lewis's paper on a great trap range through Southern Pennsylvania, read at the late meeting of the American Association for the Advancement of Science; because the discussion which followed the reading of that paper would not appear in the volume of the Transactions of the Association.

Trap Dykes in the Archæan Rocks of Southeastern Pennsylvania.

By Dr. Persifor Frazer.

(*Read before the American Philosophical Society, October 17, 1884.*)

Among the geological papers announced to be read in Section E of the late meeting of the American Association for the Advancement of Science, in Philadelphia, was one by Prof. Henry Carvill Lewis on a Trap dyke in Eastern Pennsylvania. It describes a dyke which (its author asserted) had been overlooked by the speaker and other geologists in this portion of the State, and which was distinguished, both by its great length and by certain peculiarities of position,* from other dykes in Pennsylvania.

This faulted dyke is supposed to have been laterally thrown for a distance that was understood to be five miles as Prof. Lewis described it. But on hearing that the "hade" or dips were nearly vertical in both parts which it was thought were once in contact, Prof. James Geikie thought that any previous continuity of the two dykes must be abandoned.†

In describing the course of his dyke, Prof. Lewis remarked, "Dr. Frazer failed to trace it through Chester county, though he has a small portion of it on his geological map in Easttown township; nevertheless I have followed it over the surface, foot by foot, by the loose boulders on the surface; and found it to be continuous," or words to this effect.

There happened to be on the wall the joined maps of the four counties which the speaker had prepared for the Second Geological Survey, viz: Adams, York, Lancaster and Chester, and he referred to them as follows:‡

The great amount of disintegration of the surface rocks of Chester county has caused a deep soil, which overlies a large portion of the rocks of the county on the line of this dyke, and the constant movement of this soil renders it very difficult to trace the buried outcrops by loose boulders and fragments. The consequence of this is that if one maps all the localities where masses of trap are found, and attempts to connect them by lines, the irregularity of the latter will inform him that he is probably not representing the facts of structure as they exist. In Adams county, where the decomposition is generally much less profound than in Chester, in the

* The text of this paper is not at hand and the writer must trust his memory for its contents. It is very unfortunate that in the reports of the proceedings of Sections of the A. A. A. S., there should be no account taken of the discussions on papers; especially in cases where statements are observed and pointed out which seem to be at variance with a cautious judgment of the facts. The disadvantage of this state of things to the cause to which the Association is nominally devoted is still further increased by the long period which must elapse before a paper finds its way into print. Error is notoriously fleet of foot, and with a year's start may defy pursuit.

† In a rather exceptionally full notice of this paper (omitting however mention of the objections to it) given in *Science* subsequently, the fault is stated to be several thousand feet, but the extent of the lateral displacement is mentioned only as "large."

‡ The following remarks are quoted from memory and somewhat amplified.

region of the dykes, a great deal of work was necessary before the seemingly capricious outcrops could be brought into anything like order. Let any one look at the regularity of the three threads of trap passing from N. E. to S. W. on the map of Adams county of the First Geological Survey, and compare it with the irregular and broken lines of the trap in the map of the same county by the present Survey, and he will find a case in point.

It will not suffice to find three or four occurrences of fragments of trap, lying more or less in a straight line, in a distance of a mile or more, in order to assume a dyke of trap connecting them under the soil.

On looking over the maps of the townships south of the Chester valley, which the speaker carried into the field when engaged in the Geological Survey, he remarks in a great many places notes of trap fragments on the surface. But with some experience in tracing the outcrop of this rock, he did not feel justified in connecting these isolated indications together, and he still doubts whether this should be done. The absence of a map of the dyke prevents him from saying how many of these occurrences are included within the dyke mentioned by Prof. Lewis, but no single dyke can include many of them.

It is a very different matter if it is merely claimed that this supposed new dyke indicates the direction of a zone or belt of disturbance along which two, twenty, or fifty outbursts of igneous rock may have taken place, just as it is shown that in north-western York and central Adams counties, notwithstanding all the irregularity of the outcrops, there is a general zone along which the main outflows have taken place.

The considerations which the speaker has so often urged in connection with this region, make the existence of such a belt exceedingly probable. (See Mémoire sur la partie S. E. de la Pennsylvanie, pp. 90, 109+, etc.) It has been abundantly urged, both in this memoire and elsewhere, that the exceedingly straight southern limit of the Chester valley implies other causes at work than those of ordinary deposition: in other words, a great longitudinal crack along the southern side of which the lower measures were brought up; that this great crack would in all probability be connected with others crossing or diverging from it hardly needs to be stated; but if the speaker was unable to represent this line of fracture by a single well defined dyke, there are abundant allusions both to outflows of trap and to the existence of a belt of dislocation, as the following from C_4* will show, p. 286. "The trap dyke, traceable only by its broken fragments† on the surface, which has been alluded to as occupying the southern edge of *Tredyffrin* township, enters *Easttown*," etc. (here follows a detailed statement of its course), * * * "when its traces cease to be apparent, though a few scattering boulders and fragments of trap are met with."‡

*Geology of Chester county, Persifor Frazer, edited by J. P. Lesley.

†Of course, a trap dyke may be assumed when the whole ground is made up of the larger or smaller fragments, but the question how many trap fragments will enable one to assume the presence of a dyke is, like many others, not capable of a general answer.

‡The trap here referred to is part of the "great dyke" which forms the subject of the paper above alluded to.

In the succeeding township, *Willistown*, it is stated of the rocks: "* * * Southernmost of all, a broad band of syenitic granite and hornblendic gneiss, in which latter are dykes of dolerite (as near Lukens'), and another band of serpentine. How would these facts agree with the hypothesis hinted at above, that the lower Primal was represented by the pseudo-quartz porphyry and feldspar porphyry; that this was overlain by the quartzite proper; this by schists, and this by limestone; that there had been first a synclinal valley of all these, and finally a break in or on the side of the valley, by means of which the lower measures had been thrown up on the south and planed off evenly," etc.

Under *West Goshen* township "fragments of dolerite are frequent, but no *dyke* was apparent." In the description of *West Marlborough* township, "Syenite apparently belonged to a dyke, of which the exact position was not determined," is noticed south of Doe run, and "loose pieces of dolerite were deemed insufficient to warrant the placing of this formation on the colored map" (p. 307). In the description of *East Nottingham*, fragments of syenite are mentioned, &c., &c. (p. 343).

In addition to the above references in the text of C_4 to trap, there are marks in the following localities on township maps used in the field by the speaker, which indicate the presence of igneous rock fragments which were not placed upon the county map because not sufficiently indicative of the position of the parent dyke: *East Goshen*, N.E., N. and N.W. of Goshenville; *West Goshen*, near water works; *East Bradford*, near Copesville; *East Marlborough*, near Unionville; *West Marlborough*, S.W. and N.W. of Upland, near and W. of Woodville, etc.; *Lower Oxford*, near Lincoln University, etc.; *Easttown; Willistown*, near White House P.O., N. and N.W. of Sugartown; *Highland*, near Gum Tree and near Fairview School House; *Kennett; New Gardon*, near Toughkenamon, etc.

It is not pretended that these citations cover all the places where trap was found, but they will serve to indicate that in the opinion of some field workers, there is a long step to be taken from the occurrence of a number of trap fragments on the surface to the establishment of a dyke in place.

Prof. Lewis concluded his description by saying, that such a dyke would form an important feature in the geology of the State. In this the speaker agreed with him, though whether or not the line of the trap be as continuous as he has represented it, the belt of disturbance had been established long ago.

But this dyke, if established, would be singularly confirmatory of the long fault and southern upthrow, which constitute the kernel of the speaker's hypothesis of the structure of the rocks in Southeastern Pennsylvania: for, that there should be a fracture filled with injected rock, following just the course which the speaker has ever maintained the fault to occupy, for "ninety miles;" and that the upthrow in one place (not in Chester county) was, "several thousand feet," in extent, would be clearly corroboratory of the speaker's view.

The position of this belt is indicated, C_4 (*l. ci.*), as follows: * * * "These slates are bordered by a great belt of serpentine, of which the northern boundary is nearly parallel with the southern margin of the limestone itself, as if the mass of schists intervening had about a uniform thickness, and that the serpentine were a true contact formation occurring between these schists and the lower rocks."

Attention was drawn to another statement of Prof. Lewis, viz: that the lithological characteristics of this dyke were constant throughout its range. This was entirely at variance with the speaker's observation. There were strongly marked differences of texture, structure, and constitution between many of these outcrops in the townships south of the Chester valley, and near Conshohocken.

On Herderite. By F. A. Genth.

(*Read before the American Philosophical Society, October 17, 1884.*)

In the American Journal of Science [3], xxvii, 135–138, in an article on Herderite, by William Earl Hidden and James B. Mackintosh, the latter published his analysis of this rare mineral from Stoneham, Me. In a letter to the editors of the "Neue Jahrbuch der Mineralogie, &c.," of 1884, ii, 134–136, Professor A. Weisbach gives the results of a comparative examination of the *original* herderite from Ehrenfriedersdorf, Saxony, and of that of Stoneham, Me., made at his suggestion by Dr. Cl. Winkler.

These investigations, showing remarkable discrepancies not only between Dr. Winkler's analyses of the herderite from the two localities, but also between those of the two analysts of the Stoneham mineral, it was desirable to re-examine this interesting species.

I am under great obligations to Mr. George F. Kunz, who has kindly furnished me with the material for this investigation, from which I was able to pick out over 2.5 grms. of pure crystals.

Referring to the occurrence of herderite, he has sent me the following communication, dated New York, October 14th, 1884:

"On revisiting the Stoneham locality I found that the herderite had all been "obtained from a vein of margarodite, four feet wide, about twenty feet long, "worked to a depth of ten feet. This vein is on the side of the top of Harndon "hill, about one hundred feet from the place where was found the topaz obtained "by me (see Proceedings New York Academy of Science, November and De- "cember, 1882, and American Journal of Science, Feb., 1883), and not in the same "pocket, as stated in the article, in the American Journal of Science, Jan. 7, "1884. The vein is almost entirely margarodite, occurring here in unexampled "crystals. These at times cover spaces four or five inches square with distinct "perfect crystals of margarodite, also altering to serpentine, and associated "with it what is possibly topaz, altered into serpentine.

"The herderite occurs almost invariably in crystals, implanted on the mar- "garodite, crystals of quartz, and in a few instances on columbite.

"Between the herderite vein and the topaz vein worked by me were found the "large columbite and triplite. Two distinct crystals of triplite have been found "recently.

"Signed, GEORGE F. KUNZ."

The analysis of herderite presents great difficulties, and the following methods have been used in the different analyses:

I. A portion of the material was slightly yellowish, and probably contaminated with a trace of mica. 1.0334 grm. were slowly ignited to a bright red heat in a well covered platinum crucible, and lost 4.80 per cent; after ignition, the lid and outside margin of the crucible were found coated with a film, which, when moistened with water, gave a strongly acid reaction.

About equal weights of silica and the mineral were fused with about six parts of sodium carbonate for one hour. The well-fused mass, which was greenish from a minute quantity of manganese, was lixiviated with water and should now have contained *all* the phosphoric acid, and fluorine. The silica in the solution was precipitated by ammonium carbonate, and from its filtrate the remaining silica by zinc oxide, dissolved in ammonium carbonate and ammonia. From the filtrate of the zinc silicate after evaporation to dryness and dissolving in water, the greater portion of the sodium carbonate was neutralized with dilute nitric acid, then precipitated with silver nitrate, keeping the liquid slightly alkaline. In the filtrate the balance of the fluorine (which had not been expelled by ignition), was precipitated together with calcium carbonate by calcium chloride. The mixed precipitate was ignited, dissolved in acetic acid, evaporated to dryness, the calcium acetate dissolved out by water and the calcium fluoride determined. It gave 1.57 per cent which would give, with that driven off by ignition, about 6.4 per cent.

The zinc silicate precipitate was found to contain phosphoric acid.

The portion insoluble in water was dissolved in a little hydrochloric acid and the clear solution precipitated by ammonia, and this separation twice repeated, and washed, until the filtrate was free from lime. The precipitate was ignited and weighed. It gave over 37 per cent and contained a large quantity of phosphoric acid. It was then re-dissolved in hydrochloric acid, the excess driven off by evaporation, then dissolved in water and enough sodium hydrate added to re-dissolve the greater portion of the precipitate. From the filtrate of the insoluble portion the phosphoric acid was precipitated by baryum hydrate as baryum phosphate; in the filtrate from this the excess of baryum was removed by sulphuric acid, and from the filtrate of the baryum sulphate, the glucina and alumina were precipitated with ammonia. The residue insoluble in sodium hydrate contained about 4.5 per cent of lime, nearly 3 per cent of phosphoric acid, a little iron and glucina and alumina, which latter were added to the ammonia precipitate.

These were then re-dissolved in as little acid as possible, precipitated by ammonia, and the separation of glucina from alumina attempted by that method, recommended by the highest authorities as the most perfect, namely, boiling these hydrates with a concentrated solution of ammonium chloride. The strength of the solution was kept so, that on

cooling a small quantity of ammonium chloride crystallized out. It was boiled briskly for a whole day, and did not show any bumbing at all; a large insoluble residue remained. It had a slightly yellowish color from a little iron, but had not the slimy gelatinous appearance which alumina would have presented, but, on the contrary, it was, without being crystalline, more granular and resembled beryllium hydrate precipitated on boiling from a dilute solution in sodium hydrate. The filtrate was precipitated with ammonia and gave 5.61 per cent of ignited beryllium oxide. That portion insoluble in ammonium chloride dissolved readily in a minute quantity of dilute hydrochloric acid. Sodium hydrate was now added and the whole evaporated in a platinum dish to a pasty consistency, then diluted with cold water and the little ferric hydrate filtered off, which was subsequently dissolved in hydrochloric acid, precipitated by ammonia. In washing the iron precipitate the filtrate became gradually more and more turbid. It was still more diluted with water and boiled for about one hour, when it was filtered off and washed; it gave 8.99 per cent.* The filtrate was now acidulated with hydrochloric acid and precipitated by ammonia and gave 0.17 per cent of alumina, which was dissolved in hydrochloric acid and precipitated by ammonia and was found to be insoluble in ammonium carbonate.

The different constituents were added together and gave the results given below. A considerable quantity of phosphoric acid was lost probably in the zinc silicate before I was aware of the fact that this retained such a large portion of it, and only 41.76 per cent were obtained.

II. 0.8608 grm. of finely powdered perfect crystals, dried over one week over sulphuric acid, were fused with twice their weight of silica and sodium carbonate, and the mass treated as in I. It was found, however, that for this mineral this method, even with such an excess of silica, cannot be used advantageously, as the phosphoric acid, notwithstanding the most careful operations, was contaminating almost every precipitate and was largely contained in the zinc silicate. After the greater portion of the phosphoric acid was obtained, there was still about 4.5 per cent with the glucina and ferric oxide, from which it was separated by ammonium

* This unexpected behavior of glucina with a boiling solution of ammonium chloride induced me to make the following experiments: A quantity of beryllium carbonate, prepared from beryl, from Acworth, N. H., was dissolved in hydrochloric acid, to the strongly acid solution ammonia was added until it showed a slightly alkaline reaction. It was boiled briskly for one day, then filtered, the undissolved residue was again dissolved in an excess of hydrochloric acid, precipitated by ammonia and boiled for another day and filtered. The two filtrates were mixed and precipitated by ammonia and gave 0.1158 grm. of beryllium oxide. The insoluble residue was dissolved in just enough hydrochloric acid precipitated and redissolved by sodium hydrate, diluted with much water and boiled for one hour. The precipitate weighed after ignition 0.1424 grms. Both were converted into anhydrous sulphates, the first furnishing 0.4742 grm. containing $SO_3 = 75.58$ and $BeO = 24.42$; the second gave 0.5912 grm. sulphate of beryllium with $SO_3 = 75.95$ and $BeO = 24.05$.

molybdate. The excess of molybdic acid was removed by precipitating the slightly acid solution by nitrate of lead. The excess of lead and trace of molybdenum were precipitated by hydrogen sulphide, and from the filtrate the glucina, ferric oxide and alumina separated by sodium hydrate as in I. I am afraid that a portion of the fluorine was lost in a similar way. The ignited calcium fluoride was treated with sulphuric acid and weighed as calcium sulphate, and, as probably a little silica was there which was volatilized as silicon tetrafluoride, it lost 1 per cent, and gave only 6.04 per cent of fluorine.

III. 0.3303 grm. of the same material as I, was intimately mixed with a known quantity of freshly ignited plumbic oxide, and put in a small platinum crucible with close cover, this was placed in a larger platinum crucible which had some magnesia in the bottom, it was then tightly covered and gradually heated to a strong red heat, which was continued for twenty minutes. After cooling the small crucible had sustained a loss of 0.0020 grm., which would represent 0.61 per cent. The contents of the crucible were completely fused and the lid showed a slight film. As lead fluoride is slightly volatile, it is a question whether this very small loss may not be owing to this, and that the mineral is anhydrous.

The fused mass was dissolved in acetic acid and filtered, the residue, consisting mostly of lead phosphate and fluoride, was dissolved in diluted nitric acid. A pulverulent residue, containing amongst other substances calcium fluoride, was filtered off, the fluorine driven off by sulphuric acid and the sulphates added to the other portion of the analysis. It was found that a considerable portion of the lead phosphate had gone in solution, therefore all the liquids, from which the lead had been removed by hydrogen sulphide, were united and the analysis finished as under II.

IV. 0.5860 grm. of the very finely powered perfect crystals from another specimen with traces of albite was placed in a platinum crucible moistened with water, and then sulphuric acid was added and it was evaporated until copious fumes of sulphuric acid went off. It was dissolved in water and hydrochloric acid. A very slight portion, 0.0070 grm., escaped the decomposition and was therefore deducted from the original quantity. The solution was precipitated by ammonia which would precipitate all the glucina, alumina, ferric oxide and a part of the lime in combination, with all the phosphoric acid, and would leave the calcium which was in combination with the flourine in solution. I found that 13.16 per cent had not been precipitated, which corresponds to 8.93 per cent of fluorine, which is probably more correct than 6.04 per cent as found by direct determination. The precipitate by ammonia was dissolved in nitric acid, the phosphoric acid precipitated by ammonium molybdate and the analysis finished as above.

To my four analyses I add for comparison those of Mr. Mackintosh and Dr. Winkler.

	Stoneham.						Ehrenfriedersdorf.	
	I	II	III	IV	Mackintosh.	Winkler.	Winkler.	
P_2O_5 =	41.76	43.01	43.38	43.43	44.31	41.51	42.44	
BeO =	14.60	15.01	15.17	15.04	15.76	14.84	8.61	
Al_2O_3 =	0.17	0.22	0.09	0.20	——	2.26	6.58	
Fe_2O_3 =	0.48	0.31	0.49	0.15	——	1.18	1.77	
MnO =	0.09	0.08	0.12	0.11	——	——	——	
CaO =	33.96	34.06	33.74	33.65	33.21	33.67	34.06	
H_2O =	——	——	?0.61	?0.61	——	6.59	6.54	
Fl =	——	?6.04	——	8.93	11.32			
				102.12	104.06			
Less O =				3.76	4.76			
				98.36	99.84			

Silicic acid and the alkalies belonging to the albite, etc., have not been determined, it should be remembered however that 0.20 alumina represents one per cent of albite.

The analysis made by Mr. Mackintosh and myself show that herderite is anhydrous beryllium-calcium phosphate and fluoride,—with traces only of alumina and ferric oxide and perhaps a little water. The traces of alumina are owing to slight admixtures of traces of mica and albite.

Somewhat doubtful is the exact quantity of fluorine which it contains. Mr. Mackintosh determined its quantity from the excess of lime which he found. A determination which I have made in the same manner gave me a far lower result, instead of 11.32, only 8.93 per cent. My direct fluorine determination is probably too low, owing to the incomplete decomposition of the mineral by fusion with silica and sodium carbonate and the difficulties in the separation of fluorine from such a solution. A doubt also exists as to the 0.61 per cent loss by fusion with plumbic oxide, whether it is water or lead fluoride.

As all my material was used up I could not attempt any other determination for clearing up these doubtful points.

It is to be regretted that the results of Dr. Winkler's two analyses are so very unsatisfactory, and that he has sacrificed the very precious Ehrenfriedersdorf herderite by employing incorrect methods for his analyses.

By ignition he has volatilized the greater portion of the fluorine, then by evaporation with nitric acid the rest may have gone (although nitric acid is less liable to drive off hydrofluoric acid than hydrochloric acid would be); therefore when he subsequently tested for fluorine, there was no more left than sufficient to give a *doubtful reaction.*

Although it is stated (Rose's Qual. Analyse, Leipzig, 1867, p. 212), incorrectly as I believe, that boiling with sodium acetate does not precipitate

glucina, I am not aware that this method has ever been suggested to separate glucina from alumina by boiling a solution, nearly neutralized with sodium carbonate, with sodium acetate. It is a known fact (see Graham-Otto's Anorganische Chemie, by Michaelis, iii, 2 Hälfte, p. 694) that from a solution of beryllium chloride the glucina is precipitated on boiling with sodium acetate.*

Dr. Winkler does not state that he has tested his so-called *alumina* for its purity, which is unfortunate, or he would have found that a slight trace of it might have been present, but that the precipitate was nearly pure glucina. *There can be very little doubt that the Ehrenfriedersdorf and Stoneham mineral are identical in composition.* There is also a larger percentage of ferric oxide in Dr. Winkler's analysis than found by me. Might this not have come from the molybdic acid which he used? The ammonium molybdate—prepared from Merk's molybdic acid—which I use contains in 100^{cc} 0.002 grms. ferric oxide. As I used measured quantities, a corresponding amount of ferric oxide was deducted.

UNIVERSITY OF PENNSYLVANIA, *Philadelphia, October 17, 1884.*

Notes on the Natural Bridge of Virginia. By Charles A. Ashburner.

(*October 3, 1884; see page 690.*)

During a recent trip to Virginia (September 2 to 6), I visited the Natural Bridge, and although in possession of the tourist guide book of the locality (edition of 1884) and the admirable articles published by Major Jed. Hotchkiss in "The Virginias," I failed to obtain certain information relating to the bridge which would be of special interest to the topographer and geologist. Some of the observations which I made, although of a general character, may be of interest to members of the American Philosophical Society.

The bridge is undoubtedly the remnant of the top of a cave which was

* In order to show the value of the method used by Dr. Winkler for the separation of alumina and glucina, a quantity of beryllium carbonate was dissolved in hydrochloric acid, evaporated to dryness, diluted with about 150^{cc} of water, nearly neutralized with sodium carbonate, then about 2 grams of sodium acetate were added and the solution heated. At about 80° it became turbid, and after two hours boiling a considerable precipitate had formed, which was filtered off and washed. It was dissolved in dilute hydrochloric acid, then sodium hydrate was added to redissolve the precipitate, then it was diluted with much water and gave on boiling beryllium hydrate, which after ignition weighed 0.0855 grams. The filtrate from the precipitate produced by sodium acetate was precipitated by ammonia and gave 0.2705 grm. This shows that 24.3 per cent were precipitated by boiling, and that the method is worthless for the separation of glucina from alumina. By a greater dilution and a more strict neutralization perhaps all the glucina might have been precipitated.

probably formed long before the Luray Cavern, which is excavated out of the same limestone formation. The bridge seems to be located in the centre of a gentle basin or syncline in the strata, which may account for the roof of the ancient cavern being left at this special point. The height of the bridge has evidently been much augmented by a lowering of the bed of Cedar creek through the agency of chemical and mechanical erosion after the destruction of the original cavern. The height of the cavity at the point where the bridge now exists being in consequence very much less than the present height of intrados of the bridge arch.

The elevation above ocean level of the railroad track at Natural Bridge Station on the Shenandoah Valley R. R., is 760 feet, and the elevation of Cedar creek under the north face of the bridge arch is 915 feet, as determined by two independent lines of barometric levels which I ran from the railroad station to the bridge. The height of the crown of the arch on the north side at the "Lookout Point" is 188 feet above the creek, measured with a cotton twine, which was the only line of the required length which could be obtained. The same measured by barometer (Short and Mason aluminium aneroid), was determined as 186 feet. Neither of these methods of measurements are sufficiently exact to permit of a final statement, but are of interest in the absence of more definite data. The thickness of the arch under the crown on the north side is approximately 46 feet, and on the south side 36 feet.

Much has been written and published about this Natural Bridge since the appearance, a century ago, of the Travels of the Marquis de Chastellux in North America, in 1780–2, but there appears to be a lack of a complete description of the bridge and its surroundings which is readily available, which would prove of special value to the topographer and geologist.

Stated Meeting, November 7, 1884.

Present, 18 members.

President, Mr. FRALEY, in the Chair.

Col. Ludlow, Dr. Randolph, and Mr. Dickson, new members, were introduced to the presiding officer and took their seats.

Letters of acknowledgment were received from the Royal Academy at Madrid (XVI, i, 113, 114); the Society of Antiquaries of London (415); and the Maine Historical Society (115).

A letter of envoy was received from the Meteorological Office, Royal Society, London.

Donations to the Library were reported from the Royal Academy of Belgium; the Annales des Mines; the Revue Politique; the Meteorological Council of the Royal Society, and London Nature; the Cambridge Philological Society; the Natural History Society at Montreal; the Boston Society of Natural History; the American Philological Association at Cambridge; the American Journal of Science; the American Chemical Journal; the Franklin Institute; Pennsylvania Historical Society; Prof. J. P. Lesley; Mr. Henry Phillips, Jr.; Mr. A. E. Foote; the Wyoming Historical and Geographical Society; the Commissioners of Education; the Secretary of the Navy; the United States Fish Commission; the United States National Museum; the United States Naval Observatory; the Smithsonian Institution; the American Journal of Mathematics; Major Jed. Hotchkiss, of Staunton, Va.; the editor of the Western Magazine, Cleveland; the Colorado Scientific Society; the Astronomical Observatory of Mexico, and the Imperial Observatory of Rio de Janeiro.

Dr. Rushenberger accepted his appointment to prepare an obituary notice of Dr. R. E. Rogers.

Mr. Vaux accepted his appointment to prepare a notice of Mr. Henry M. Phillips.

The death of Mr. John Biddle, of Philadelphia, October 19, aged 70 years, was announced.

The death of Mr. C. E. Rawlins, of Liverpool, aged 71 years, was announced.

Dr. Syle exhibited copies of the Shanghai Chinese Illustrated News, picturing the defeat of the French troops by the Chinese in the late battles; and described the peculiarities of the structure of the Chinese language.

Prof. Cope presented "An Analysis of the bark of the *Fouquieira splendens*," by Miss Helen C. D. Abbott.

Prof. E. D. Cope mentioned some of the results of his studies on the Batrachian and Reptilian fauna of Mexico and Central America, which had been prosecuted by the use of material mainly placed at his disposal by the Smithsonian Institution.

The total number of species described up to date is six hundred and ten, which is described as follows:

		Genera.	*Species.*	
BATRACHIA.	Urodela	6	15	120
	Gymnophiona	4	7	
	Anura	31	98	
REPTILIA...	Crocodilia	2	3	488
	Testudinata	11	28	
	Lacertilia	42	183	
	Ophidia	92	274	

On motion of Dr. Brinton it was

Resolved. The expediency of preparing and printing a Dictionary of the Lenni Lenâpé language, based on that of the Rev. David Zeisberger, and thus completing the presentation of that language, begun in our TRANSACTIONS in 1827 by our former President, Peter Stephen Duponceau, be referred to the Publication Committee, with instructions to report at the first regular meeting in January, 1885.

Pending nominations Nos. 1031, 1032 and new nomination No. 1033, were read, and the meeting was adjourned.

Stated Meeting, November 21, 1884.

Present, 15 members.

President, Mr. FRALEY, in the Chair.

An acknowledgment of the receipt of Proceedings Nos. 112, 114, 115 was received from the Royal Zoölogical Society of Amsterdam.

A letter of envoy was received from the Librarian of the University of California.

A letter was received from the United States Department of the Interior, offering copies of the Blue Book, or Official Register of the United States.

A circular invitation was received from the Natural History Society at Bamberg, to assist at the celebration of its Fiftieth Anniversary, on November 8, 1884.

Donations for the Library were received from Mr. Paul Albrecht, of Brussels; the Geographical Society at Paris; Royal Academy of History at Madrid; Royal Meteorological and Astronomical Societies of London; London Nature; the Boston Society of Natural History; Science Record; New York Meteorological Observatory; American Journal of Pharmacy; Mr. Henry Phillips, Jr.; the Maryland Historical Society; Johns Hopkins University; United States Fish Commission; United States Department of the Interior; Kansas State Historical Society, and University of California.

The death of Eli K. Price, senior Vice President of the Society, at his residence, in South 15th street, Philadelphia, on the 11th inst., in the 88th year of his age (born July 20, 1797), was announced.

The following contributions to the Society were read:

1. Notes on the Geological Structure of Tazewell, Russell, Wise, Smyth, and Washington counties, of Virginia, by John J. Stevenson, Professor of Geology in the University of New York, with seven cross sections and a geological map.

Mr. Lesley remarked that—

This mémoir was a continuation of Prof. Stevenson's description of the Geology of Southwestern Virginia, read before the Society, August 20, 1880, January 21, 1881, and October 7, 1881; but without further reference to the economics of the region.

The absence of the Chemung and Portage and Genesee formations VIII *f*, *e*, *d*, from long outcrops in Lee, Wise and part of Scott counties (although the Chemung is present on Indian creek, &c. further east); the absence of the coarser members of the Hamilton VIII *e*, and the Marcellus VIII *b*, so that only 900 feet of black slate is left; the absence of the Upper Helderberg VIII *a*, Oriskany VII, Lower Helderberg VI, and Onondaga V *b*—leaving merely the Clinton V *a*, and Medina IV *b*, *c*, which, however, thin out and disappear themselves, *but in a southeasterly direction*—are facts of importance to the proper understanding of the original source, or rather sources of our Palæozoic deposits.

The logical discussion of facts relating to the anomalous salt and gypsum deposits along the Holston, at Saltville and elsewhere, is specially valuable. The independence of the gypsum clays as regards the Palæozoic floor-rocks on which they rest, and the evident erosion of the gypsum before the deposit of the blue clay, upon which again the *Mastodon* conglomerate lies, are important steps of an argument resulting in a theory

that the gypsum is not older than Tertiary times, and that it owes its origin (as in the Great Salt Lake of Utah) to the meeting of two systems of drainage waters, one from a region furnishing an abundance of lime water, and the other from a region furnishing an abundance of copperas water.

This memoir is not only valuable for its new facts, but for its correction of mistakes made by me in my survey of the region in 1870. A re-survey of any geological field by another, or by the same competent geologist, is sure to produce such results; and the "constants of science" can only be obtained by this process of reiteration. My mistake of identifying the fault at Saltville with the Walker mountain fault is a case in point. Prof. Stevenson shows their distinction.

The total absence of the Catskill formation No. IX, and the nearly total absence of the Pocono formation No. X, two formations measuring together in Middle and Eastern Pennsylvania at least 8000 feet, is worthy of especial notice, as it goes far to confirm the apparent lack of IX and thinness of X at no great distance behind the Allegheny mountain in western Pennsylvania. As we know nothing of the south-eastern limit of these formations, and merely see them at their last outcrop growing thicker in that direction, and also north-eastward, the idea of a closed basin, however large—perhaps extending to Scotland—may challenge respectful consideration.

On motion, the Secretaries were authorized to publish a colored map of the district like that in Vol. XIX, page 219.

2. The Limits of Stability of Nebulous Planets, by Prof. Daniel Kirkwood.

3. On the Genealogy of the Vertebrata, and the Theory of Degradation as demonstrated by it, by Prof. E. D. Cope.

The minutes of the last meeting of the Board of Officers and Members in Council were read, and on motion the recommendations therein contained were approved and adopted.

1. *Resolved*, That the Proceedings be hereafter published quarterly, or oftener, at the discretion of the secretaries.

2. *Resolved*, That all members not paying an annual contribution be charged one dollar annually for the printed Proceedings.

It was explained that the Post-Office laws of the United States require not only a quarterly issue, but a bona fide subscription list, for placing any printed matter under the head of third-class matter.

The Secretaries will not only make this notification and explanation, but will send a circular letter to such members of the Society soliciting their assent.

3. *Resolved*, That the Indian Picture Rock be obtained at a total cost not exceeding $50 for purchase, preparation and transportation.

4. That an appropriation of two hundred and seventy-five dollars ($275) be made for heliotype views of the Society's Hall, within and without, to illustrate the forthcoming Volume I, Part i, Proceedings of the Society from 1744 to 1837.

5. That a circular letter be sent to members, urging them to take measures for the preservation of the monuments of antiquity in their several localities.

6. That it is not expedient for the Society to take any part in the proposed American Exhibition in London in 1886.

The alterations made in the garrets of the Hall for purposes of storing and arranging the Society's stock of publications, were reported and approved, and the meeting was adjourned.

Stated Meeting, December 5, 1884.

Present, 13 members.

President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Judge Jas. R. Ludlow, Prof. G. vom Rath, Dr. A. S. Gatschet, and Rev. Dr. H. C. Trumbull.

Letters of acknowledgment were received from the Societas Floræ et Faunæ Fennica, at Helsingfors (107, 108, 113), asking for back numbers; from the London Royal Society (XVI, i; 112, 113, 114); from the Verein für Vaterländische Naturkunde at Stuttgart (XVI, i; 112–114); and from De Lau & Co., London (see MS. Minutes).

A letter proposing exchange of duplicates was received from the Mercantile Library.

Letters of envoy were received from the Meteorological Office of the Royal Society, London, and the Society at Helsingfors.

Donations to the Library were received from the Royal Academies at Berlin, Turin, Modena, London and Edinburgh; the Observatories at Adelaide, Oxford and Brussels; the Geologi-

cal Survey of India; the Society at Helsingfors; the Archives of Physical and Natural Sciences at Geneva; the Anthropological Society and Royal Geological Institute at Vienna; the Natural History Societies at Altenburg, Bremen, Bonn and Stuttgart; the German Geological Society; the Society of Natural and Medical Sciences at Giessen; the Horticultural Society at Görlitz; the Physical-Economical Society at Königsberg; the Geographical and Natural History Societies at Leipsic; the Astronomical, Geological and Geographical Societies at London; the Boston Society of Natural History; the Essex Institute; Museum of Comparative Zoölogy; American Journal of Science; New Jersey Historical Society; Franklin Institute, Henry Phillips, Jr., Prof. E. D. Cope; Kosmos; the Second Geological Survey of Pennsylvania; Prof. Ira Remsen, of Baltimore, and Major Hotchkiss, of Stanton, Virginia.

Mr. Henry Phillips, Jr., presented two valuable catalogues of collections of coins; one of Jerome de Vries, Jr. of Amsterdam; the other of the Marquis Remedi of Sarzani, handsomely illustrated with heliotype plates.

Prof. John J. Stevenson of the University of the City of New York communicated a paper entitled: "Some notes respecting metamorphism."

Mr. Carson read by appointment an obituary notice of the late Gen. A. A. Humphreys.

Dr. Frazer exhibited and explained his invention of a form of hand-compass, in which the needle is preserved from injury by carriage.

Mr. Ashburner exhibited and described a new map of the anthracite coal region with columnar lists of the production of each mine.

The Treasurer read his annual report, which was submitted to the Committee on Finance.

Pending nominations Nos. 1031 to 1033 were read, and the meeting was adjourned.

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him the communication, description, or model, except the officer to whom it shall be entrusted; nor shall such officer part with the same out of his custody, without a special order of the Society for that purpose.

6. The Society, having previously referred the several communications from candidates for the premium, then depending, to the consideration of the twelve counsellors and other officers of the Society, and having received their report thereon, shall, at one of their stated meetings in the month of December, annually, after the expiration of this current year (of the time and place, together with the particular occasion of which meeting due notice shall be previously given, by public advertisement) proceed to final adjudication of the said premium; and, after due consideration had, a vote shall first be taken on this question, viz.: Whether any of the communications then under inspection be worthy of the proposed premium? If this question be determined in the negative, the whole business shall be deferred till another year; but if in the affirmative, the Society shall proceed to determine by ballot, given by the members at large, the discovery, invention or improvement most useful and worthy; and that discovery, invention, or improvement which shall be found to have a majority of concurring votes in its favor shall be successful; and then, and not till then, the sealed letter accompanying the crowned performance shall be opened, and the name of the author announced as the person entitled to the said premium.

7. No member of the Society who is a candidate for the premium then depending, or who hath not previously declared to the Society, that he has considered and weighed, according to the best of his judgment, the comparative merits of the several claims then under consideration, shall sit in judgment, or give his vote in awarding the said premium.

8. A full account of the crowned subject shall be published by the Society, as soon as may be after the adjudication, either in a separate publication, or in the next succeeding volume of their Transactions, or in both.

9. The unsuccessful performances shall remain under consideration, and their authors be considered as candidates for the premium for five years next succeeding the time of their presentment; except such performances as their authors may, in the meantime, think fit to withdraw. And the Society shall annually publish an abstract of the titles, object, or subject matter of the communications, so under consideration; such only excepted as the Society shall think not worthy of public notice.

10. The letters containing the names of authors whose performances shall be rejected, or which shall be found unsuccessful after a trial of five years, shall be burnt before the Society, without breaking the seals.

11. In case there should be a failure, in any year, of any communication worthy of the proposed premium, there will then be two premiums to be awarded the next year. But no accumulation of premiums shall entitle the author to more than one premium for any one discovery, invention or improvement.

12. The premium shall consist of an oval plate of solid standard gold of the value of ten guineas. On one side thereof shall be neatly engraved a

short Latin motto suited to the occasion, together with the words: "The Premium of John Hyacinth de Magellan, of London, established in the year 1786;" and on the other side of the plate shall be engraved these words: "Awarded by the A. P. S. for the discovery of——— A.D.———." And the seal of the Society shall be annexed to the medal by a ribbon passing through a small hole at the lower edge thereof.

SECTION 2. The Magellanic fund of two hundred guineas shall be considered as ten hundred and fifty dollars, and shall be invested separately from the other funds belonging to or under the care of the Society, and a separate and distinct account of it shall be kept by the treasurer.

The said fund shall be credited with the sum of one hundred dollars, to represent the two premiums for which the Society is now liable.

The treasurer shall credit the said fund with the interest received on the investment thereof, and, if any surplus of said interest shall remain after providing for the premiums which may then be demandable, said surplus shall be used by the Society for making publication of the terms of the said premium, and for the addition, to the said premium, of such amount as the Society may from time to time think suitable, or for the institution of other premiums.

The treasurer shall, at the first stated meeting of the Society in the month of December annually, make a report of the state of said fund and of the investment thereof.